Deputy Director of Public Instruction,
(Planning), West Bengal.

Adventures in Tropical Science for Juniors

N. A. WATTS
B.SC., B.T., A.B.T.I.

Book 5

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FOREWORD

Most young children come to school eager to learn. They are alive with curiosity, on edge to explore, among other things, the wonderland of Nature, animate and inanimate. Nature Study has rightly been since the beginning of this century an essential part of the curriculum of the Primary School child; but, unfortunately, it has in too many instances meant largely a dictated series of notes to be learnt by rote rather than a real, vital contact with Nature's wonders. And even where a good text-book has replaced the exercise book filled with dictated notes, it has been generally a text-book written for English or American children, which, while excellent in itself, has had little relevance to the Indian child.

To improve and make more relevant to Indian conditions the teaching of Nature Study or Primary School Science in Anglo-Indian Schools in West Bengal, an expert Committee met in 1954 under my Chairmanship to draft a suitable graded syllabus and suggest suitable methods of teaching this important subject in the Primary School. The outcome of its findings was published by Orient Longmans in a pamphlet entitled "Suggestions for the Teaching of Nature Study and General Science in Schools in India".

Mr. Watts, who was an active member of the above Committee, has based his series of admirable text-books on the syllabus and methods outlined in the above pamphlet, and has done an excellent job of work. His series of text-books appears to me to be particularly well-suited to the needs and interests of young children in India, and will, I am sure, prove stimulating both to children and to teachers not only in Anglo-Indian Schools but in other types of progressive schools all over India and in similar regions.

Adventures in Tropical Science fills a gap in the text-book field, and I am sure will be warmly welcomed by teachers and children. I wish it every success.

AUSTIN A. D'SOUZA, M.A., B.T.
DIP.ED. (LOND.), A.I.E. (LOND.)
Inspector of Anglo-Indian Schools, West Bengal

Deputy Director of Public Instruction

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PREFACE

THE conception of science taught in the Junior School must not be falsified or distorted by an exaggerated importance placed on the accumulation of knowledge to be acquired and crude, inert blocks of data to be stored. The subject must be planned along lines that are vivid and unencumbered by the dead-wood of a formal tradition, quickened by inquiry, initiative and ingenuity; refusing to be distracted by methods which have for their criterion an attachment to conventional orthodoxies, rather than an appraisement of the essential needs and possibilities of the children themselves. New avenues should be explored, by which the pupils leave the beaten path and strike out fearlessly, predominated by curiosity, into new fields: which is the very soul of education. Assimilation and appreciation of Science must be a lively, realistic process, cultivating the imagination and fostering social spirit; a stream in motion, not a stagnant pool.

In composing the five books in this series the author does not pretend to have made any startling discoveries or to have enunciated novel truths; rather is this an attempt to create and instil in the minds of children, according to their maturity levels, a provocative interest and an understanding of the wonder and variety of the world in which they live. Sedulously applied it may be expected to impart a meaning and motive to the child's initial experience of the miracle of life.

The teacher must formulate a philosophy of teaching adjusted to suit the conditions and needs of the neighbourhood. It should be flexible, adaptable and developing in its nature, subject to modification with the introduction of new evidence. In the ultimate analysis, each method of teaching should appeal to the emotion of the children, relying less on mass-instruction and more on the encouragement of individual and co-operative effort, resulting in the pooling of material and ideas, so that the school may be regarded not as the antithesis of life, but as its complement and commentary.

N. A. WATTS

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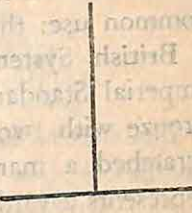
PART 1 — PHYSICS

I

The Measurement of Length

Look at the two lines drawn on this page. Can you say which is longer? The vertical line appears to be longer but only after you have measured each line and compared the two lengths will you be sure. This simple illustration of how our eyes may deceive us suggests the necessity of measurement.



Which line is longer?

When we are asked to state a measurement we give two things: a number and a name. For example, on measuring the length of a cricket pitch we may find it is 22 yards. The name yard is the unit of length and the number 22 is the number of times the unit is contained in the length of the pitch. The tool we use for the measurement of length is the scale which is usually a strip of wood of a certain definite length. Let us take a peep into past ages and see what early man used instead of the modern scale.

Long, long ago when man developed from a cave dweller to a builder of huts he realised the importance of measurement. To measure length he found it necessary to decide on some standard unit distance and then find out the number of times it was contained in the unknown distance being measured.

Many units of length which he used were taken from parts of his body. The inch was the width across the central portion of his thumb; the foot was the length of his foot; the yard was the distance from his nose to the tips of his fingers, with his arm extended; a mile was a thousand paces. These units of length were considered convenient, for everyone carried his measures about with him. We can easily imagine, however, the confusion in a market place when a man with long arms insisted on buying cloth by his own arm's length rather than accept cloth measured by a merchant with short arms.

With the expansion of trade, it became necessary for men of different countries to agree upon certain definite standards of measurement. Today, two systems of measurement are in common use: the British System and the Metric System.

British System. The British Unit of Length called the Imperial Standard Yard is kept in London. It is a bar of bronze with two gold plugs at either end. On each plug is scratched a mark and the distance between the two marks represents a yard. All yard measures that we use are copies of this standard length. To enable us to measure fractions of a yard, this unit of length has been divided into certain fixed proportions. Thus:

12 inches = 1 foot
3 feet = 1 yard

For lengths greater than a yard we have,

5½ yards = 1 pole
40 poles = 1 furlong
8 furlongs = 1 mile
3 miles = 1 league

The relationship between inches, feet, yards, poles, furlongs miles and leagues are 12, 3, 5½, 40, 8 and 3. Because of this uneven relationship between the different units, conversion of inches to leagues or leagues to inches is slow and we have to divide or multiply with awkward numbers.

Metric System. The Metric System of measurement is much easier to work with than the British System and is now being used all over the world, especially for scientific purposes. The Metric Unit of Length called the Standard Metre is kept in Paris. It is a bar made of platinum and the distance between the centres of two marks scratched on the bar represents a metre. Just as a yard is divided into fractions so also is a metre divided into smaller parts. Thus:

10 millimetres (mm.) = 1 centimetre (cm.)
10 centimetres = 1 decimetre (dm.)
10 decimetres = 1 metre (m.)

For lengths greater than a metre we have,

10 metres = 1 decametre (Dm.)
10 decametres = 1 hectometre (Hm.)
10 hectometres = 1 kilometre (Km.)

In the Metric System the measurements are in tens and this makes calculation easy and quick. Here calculation is done by decimals and conversion from one unit to another may be brought about by simply moving the decimal place.

We can make a simple conversion table which will show us at a glance how 1 Km. is related to the other units in the system.

Km.	Hm.	Dm.	m.	dm.	cm.	mm.	
1·							kilometres
= 1	0·						hectometres
= 1	0	0·					decametres
= 1	0	0	0·				metres
= 1	0	0	0	0·			decimetres
= 1	0	0	0	0	0·		centimetres
= 1	0	0	0	0	0	0·	millimetres.

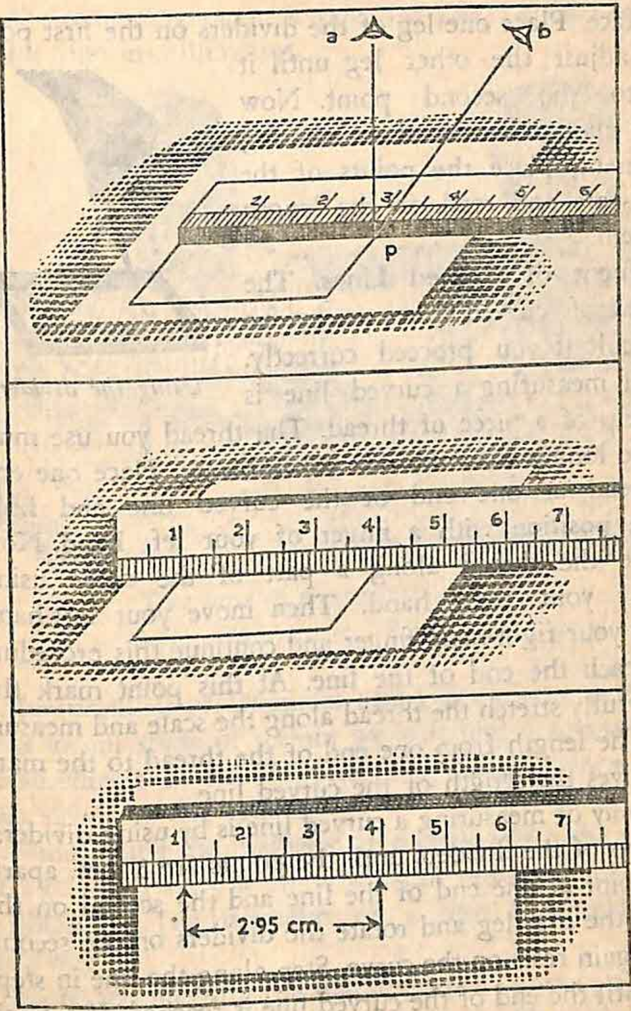
Try making a conversion table for 9,000,000 mm.

Suppose we measured the length of a room and found it to be 9 metres, 7 decimetres, 4 centimetres and 6 millimetres, then because the metric system is a decimal system, we would write the length as 9.746 m. or 97.46 dm. or 974.6 cm. or 9746 mm.

Measurement of Straight Lines. Before you begin to measure the lengths of straight lines correctly you must observe certain precautions. Firstly, you must place the scale on its edge along the line that is being measured so that the divisions on the scale are in contact with the line. By doing this you will avoid any errors due to parallax which can be understood by referring to the picture. At the point P the scale reading evidently depends upon the position of your eye. It is necessary, therefore, to look from directly over the mark while taking the reading. Secondly, as the end of the scale is generally worn away it is better to put one end of the line being measured exactly opposite the first centimetre mark and subtract one centimetre from the reading obtained. Thirdly, if the end of the line you measure does not coincide with any division of the scale but falls between two divisions it will be necessary for you to estimate the fractions of a scale division. To do this you must imagine the space between the two divisions to be divided into 10 equal parts and then estimate how many of these parts are covered. Write the measurement to the second decimal place.

To be perfectly sure of accurate results you should make several measurements and take the average of all the measurements. This is done by adding up all the results and dividing the answer by the number of results.

You will find that dividers are of great help in measurement, especially when it is inconvenient to measure directly with a scale. Thus you may use the dividers to measure the distance between two points at the bottom of a box or two points on an



Measuring a straight line with a scale

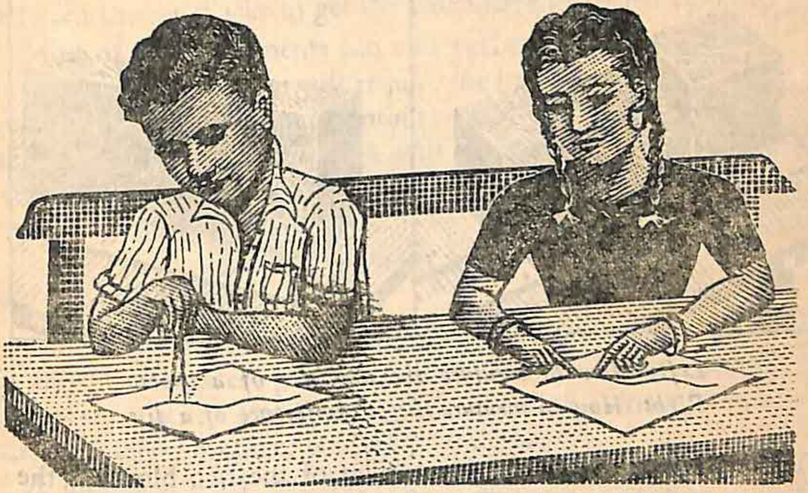
Above: Position of eye: (a) Correct position (b) Incorrect position. Centre: How to avoid parallax. Below: Estimation.

uneven surface. Place one leg of the dividers on the first point and then adjust the other leg until it stretches to the second point. Now remove the dividers, and without altering the adjustment, place the points of the legs on a scale and read off the length between them.

Using the dividers

Measurement of Curved Lines. The measurement of curved lines is by no means difficult if you proceed correctly. One way of measuring a curved line is with the help of a piece of thread. The thread you use must obviously be longer than the line you measure. Place one end of the thread at one end of the curved line and hold it firmly in position with a finger of your left hand. Now slowly trace the thread along a part of the curve using a finger of your right hand. Then move your left-hand finger up to your right-hand finger and continue this procedure until you reach the end of the line. At this point mark the thread. Carefully stretch the thread along the scale and measure its length. The length from one end of the thread to the mark you made gives the length of the curved line.

Another way of measuring a curved line is by using dividers. Open the legs of the dividers until the points are 3 mm. apart. Place one point at one end of the line and the second on the curve. Raise the first leg and rotate the dividers on the second leg until it again rests on the curve. Step along the line in steps of 3 mm., until the end of the curved line is reached. If a small portion of the line is left you must measure it separately with the dividers. Count the number of steps taken by the dividers and multiply this number by 3. Add the answer to the length of the remaining piece of line and you will know the length of the line in millimetres.

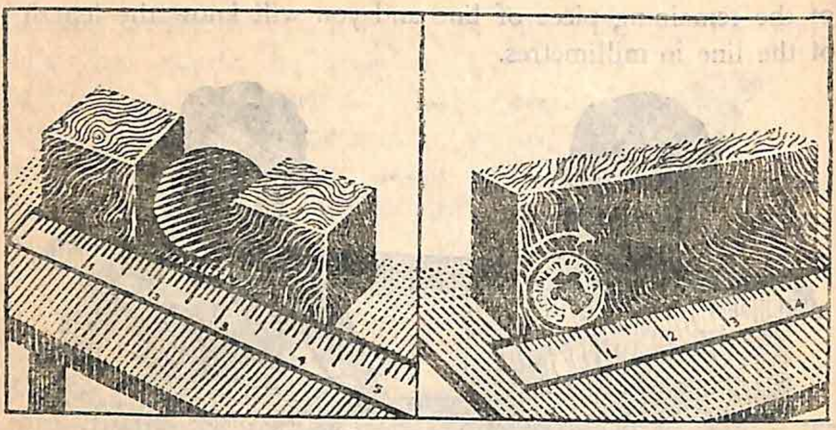


Two ways of measuring a curved line
Left: with dividers. Right: with thread.

Measurement of Diameter and Circumference. As we progress in our study of science we will find it necessary to take measurements of the diameter and circumference of circles, discs, cylinders and spheres.

In measuring the diameter of a circle place the scale across the circle and shift it slightly about until the longest length is obtained. The diameter of a disc is obtained in the same way.

Before you measure the diameter of a sphere you will need two large rectangular blocks of wood. Place the blocks in contact with the edge of the scale. Now fit the sphere between the two blocks so that it touches both the blocks on either side.



Left: How to measure the diameter of a sphere
Right: How to measure the circumference of a disc

The distance between the inner sides of the two blocks is the diameter of the sphere. The same method may be used to get the diameter of a cylinder.

Thread or dividers will help you to measure the circumference of a circle.

To measure the circumference of a disc you must first make a mark with ink on one face of the disc. Place a block of wood close to the scale and stand the disc on its edge making sure that it lies flat against the side of the wooden block. Now roll the disc along the scale noting where the ink-mark touches the scale. After the disc has made a complete revolution note where the ink mark again touches the scale. The distance travelled by the disc will give you its circumference.

The circumference of a cylinder may be measured as follows. Smoothly wrap a thin strip of paper once round the cylinder so that the ends overlap one another. Prick through the paper with a pin. Now unroll the paper and measure the distance between the pin-pricks to get the circumference of the cylinder.

Most of the experiments you will perform during the course of your study of science will require the measurements of some quantity or other. By experimenting carefully, observing honestly and measuring accurately you will understand many of the wonderful things in the world around you.

Things to make and do

Fill in the blanks:

Choose the correct words from this list and use them to fill in the blank spaces:- parallax, circle, definite, metre, thread, diameter, metric, centimetre, yard, standard, circumference, scale, dividers, average, constant, fractions.

A unit is a fixed —— quantity which is used as a —— of reference, and by its constant application other quantities of the same kind are measured. The Imperial Standard —— is the British unit of length. The Standard —— is the Metric unit of length. The —— system of measurement is used for all scientific measurements.

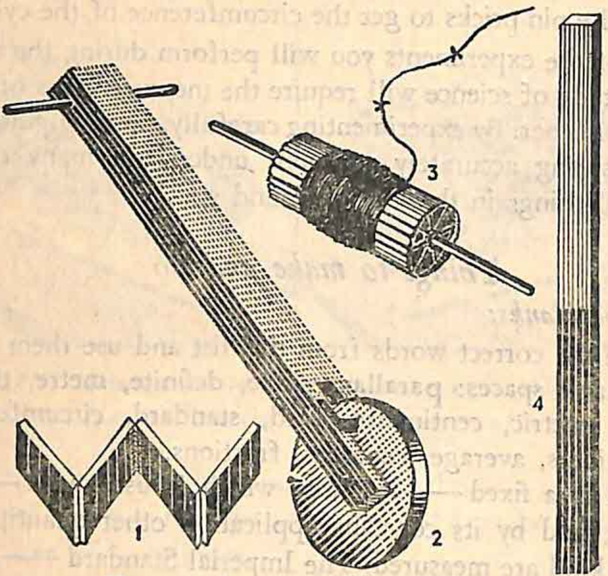
When we measure straight lines with the use of a —— we must measure from a —— division, estimate —— of a scale division, avoid —— and make several measurements taking the —— of all the measurements as correct. When we measure curved lines we must use the —— or a piece of ——.

In the case of a —— or a sphere the length of the —— divided by that of its —— is a —— quantity.

Measuring equipment:

1. Make a folding scale as follows. Cut strips of cardboard into definite, uniform lengths. Mark each strip into centimetres.

Join the strips to one another with gummed paper.



Home-made measuring equipment
1. *A folding scale.* 2. *A measuring scooter.*
3. *A measuring string.* 4. *A metre stick.*

2. A metre stick can be made from a strip of wood measuring one metre. Divide the strip into two parts. Paint each part a different colour.

3. A measuring string with knots tied at intervals of 25 cm. will help you to measure curves.

4. A few pieces of wood, nails, a wooden wheel and a strip of metal are all the materials you need to make a measuring scooter. Before you use your scooter measure the distance covered by one complete revolution of the wheel. The nail on the wheel will strike against the metal strip after each revolution and help you to keep count.

In the school compound:

With the help of your measuring equipment make a map of the school premises.

For your wall newspaper:

Draw a graph to show the relationship of inches to centimetres. (*Hint*: 1 in. = 2·54 cm.) The graph will help you to convert inches to centimetres or centimetres to inches without the need of any calculation.

In your note-book:

1. Draw five circles each having a different radius. Measure the circumference of each circle using either dividers or thread. Multiply the radius of each circle by two to obtain its diameter. Divide the circumference of each circle by its diameter, and enter the results in the following table:

Number of circle	Diameter in cm.	Circumference in cm.	$\frac{\text{Circumference}}{\text{Diameter}}$
1			
2			
3			
4			
5			

You will notice that the value obtained by dividing the circumference of each circle by its diameter is a constant quantity. Thus,

$$\frac{\text{Circumference}}{\text{Diameter}} = 3{\cdot}14$$

This value is represented by a letter from the Greek alphabet π (pi). Hence we write,

$$\frac{\text{Circumference}}{\text{Diameter}} = \pi$$

Use this formula to calculate the circumference of a sphere, having first determined its diameter by measurement.

2. Turn to a map of India in your atlas. Measure the distance between any two lines of latitude to the nearest tenth of a centimetre. Use the scale marked on the map to calculate the number of kilometres that would correspond to 360 degrees of latitude. Your answer is the circumference of the earth. Calculate the approximate diameter of the earth.

2

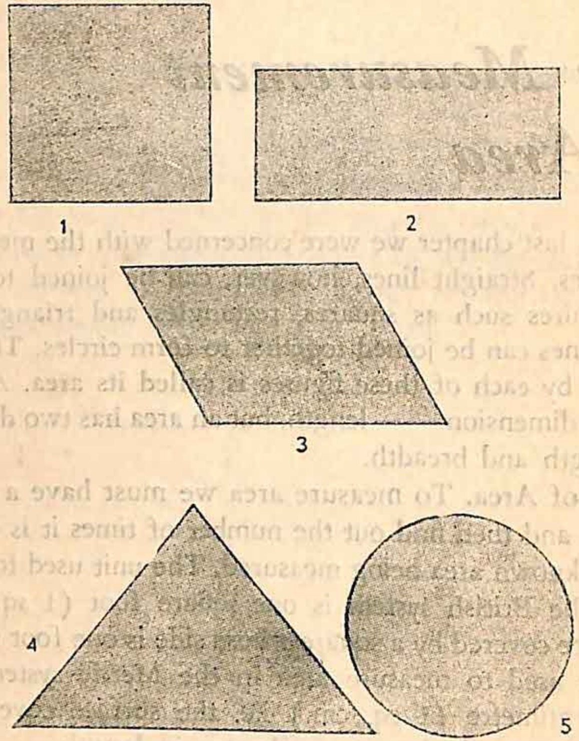
The Measurement of Area

IN THE last chapter we were concerned with the measurement of lines. Straight lines, however, can be joined together to form figures such as squares, rectangles and triangles, while curved lines can be joined together to form circles. The surface enclosed by each of these figures is called its area. A line has only one dimension —— length, but an area has two dimensions —— length and breadth.

Units of Area. To measure area we must have a standard unit area and then find out the number of times it is contained in the unknown area being measured. The unit used to measure area in the British system is one square foot (1 sq. ft.) i.e. the surface covered by a square whose side is one foot in length. The unit used to measure area in the Metric system is one square centimetre (1 sq. cm.) i.e. the surface covered by a square whose side is one centimetre in length.

Areas of Regular Figures. When we say that a figure has an area of one square centimetre, it does not mean that the figure must be a square, but that it occupies the same amount of surface as a square having a side equal to one centimetre in length. The figures drawn on page 14 are of different shapes but are all equal in area.

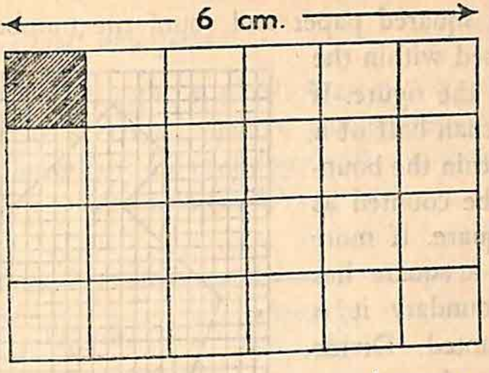
To find the area of a regular figure such as a rectangle we imagine it to be broken up into a number of equal squares each having an area of 1 sq. cm. In the rectangle shown on page 15



Regular Figures
1. *Square.* 2. *Rectangle.* 3. *Parallelogram*
4. *Triangle* . 5. *Circle.*

there are four rows of squares with six squares in each row. Th area of the rectangle is therefore 6×4 = 24 sq. cm. In commo practice the area of a rectangle is found by using the formula

Area of a rectangle = length × breadth.

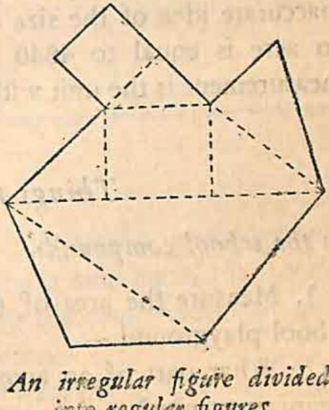


A rectangle divided into equal squares

There are a number of other formulæ which are used to calculate the areas of common regular figures.

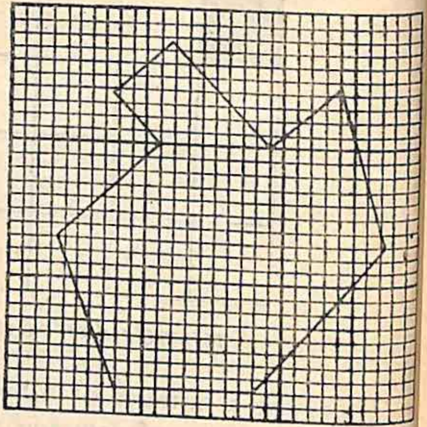
Area of a triangle = $\frac{1}{2}$ base × perpendicular height
Area of a circle = $\pi \times (\text{radius})^2$

Areas of Irregular Figures. One way of finding the area of an irregular surface is by dividing the surface into suitable parts such as rectangles, triangles or circles and then adding up the calculated areas of the different parts. The second method of obtaining the area of an irregular surface is by the use of squared paper.



An irregular figure divided into regular figures

Choose squared paper divided into large squares each having an area of one square inch and composed of a hundred small squares. Trace the outline of the given irregular figure on the squared paper and count the number of small squares enclosed within the boundary of the figure. If half or more than half of a square lies within the boundary it is to be counted as one whole square. If more than half of a square lies outside the boundary it is not to be counted. Divide the number of squares counted by 100 and thus obtain the area of the irregular figure in square inches.



Use of squared paper to find the area of an irregular figure

In olden times an acre was the area of land one man with a yoke of oxen could plough in one day. With the advancement of science and the establishment of proper systems of measurement the old, inaccurate idea of the size of an acre was changed. Nowadays an acre is equal to 4840 sq. yds. This definite standard of measurement is the unit with which farmers measure their land.

Things to make and do

In the school compound:

1. Measure the area of (*a*) the school garden and (*b*) the school playground.

2. What part of an acre or how many acres do the school premises occupy?

For your wall newspaper:

Draw a rectangle, a parallelogram, a triangle and a circle on separate sheets of squared paper. Obtain the area of each by calculation and by counting squares as previously explained. Enter your results in the following table:

Figure	Area by calculation	Area by counting squares
Rectangle		
Parallelogram		
Triangle		
Circle		

In your note-book:

1. Find the number of square centimetres in one square inch as follows. Draw a square having a side equal to one inch in length. Measure the length using the centimetre scale and calculate the area in square centimetres.

2. How many (*a*) sq. mm. (*b*) sq. cm. (*c*) sq. dm. are there in a sq. m. ?

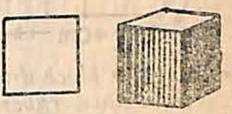
How to find the area of a country:

Trace the outline of the map of the country on tracing paper. Then transfer the outline on to squared paper. With the help of the scale on the map calculate the number of square miles equal to one square inch. Now find out the area of the country by the method of counting squares.

3

The Measurement of Volume

SQUARES and rectangles are figures which possess only tw dimensions: length and breadth. They are called plane figures. There are other figures which possess three dimensions: length, breadth and height. These are called solid figures. A plane figure is enclosed by lines and occupies a surface called its area. A solid figure, however, is enclosed by surfaces and occupies a space called its volume. A cube is an example of a solid figure that has six equal square surfaces.

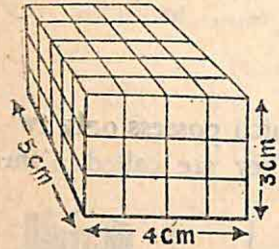


Comparison of plane and solid figures
Left: a square centimetre
Right: a cubic centimetre

Units of Volume. To measure volume we must have a standard unit volume and then find out the number of times it is contained in the unknown volume being measured. In the British system the unit used to measure volume is one cubic foot (1 cu. ft.) i.e. the space occupied by a cube whose side is one foot. In the Metric system the unit used to measure volume is one cubic centimetre (1 c.c.) i.e. the space occupied by a cube whose side is one centimetre. The unit of volume in the Metric system is chosen for all scientific purposes.

Volumes of Regular Solids. When we say that a solid has a volume of one cubic centimetre, it does not mean that the solid must be a cube, but that it occupies the same amount of space as a cube having a side equal to one centimetre in length.

To find the volume of a regular solid such as a rectangular block we imagine it to be broken up into a number of equal cubes, each having a volume of one cubic centimetre. We first find how many cubes are in the bottom layer and multiply this number by the number of layers. Thus:



A rectangular block divided into equal cubes

Volume of a rectangular block
$= \text{area of base} \times \text{height}$
$= \text{length} \times \text{breath} \times \text{height}$

There are a number of other formulæ which are used to calculate the volume of common regular solids:

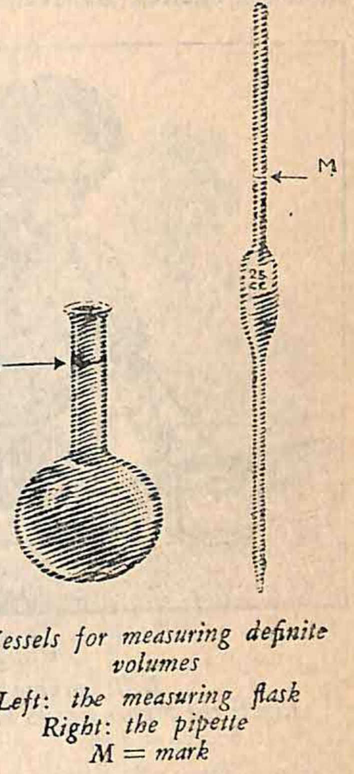
Volume of a cube = $(\text{length})^3$
Volume of a cylinder = $\pi \times (\text{radius})^2 \times \text{height}$
Volume of a sphere = $4/3 \times \pi \times (\text{radius})^3$

Volume of Liquids. Liquids, like solids, occupy space. Unlike solids, however, they take the shape of the vessel in which they are contained. Certain vessels have been specially designed and graduated to measure the volume of liquids.

When definite volumes of a liquid are required the pipette and the measuring flask are used.

Pipettes are made in sizes to deliver small, definite volumes of a liquid i.e. 5, 10, 20, 25 or 50 cubic centimetres. A pipette is a narrow tube with a bulb in the middle and tapering at its lower end to form a jet. On the upper portion of the pipette is a circular mark scratched on the glass. When liquid fills the pipette up to this mark the volume is as indicated on the bulb.

To use the pipette put the lower end in a liquid and the other end in your mouth. Now suck the air out of the pipette. The pressure of the atmosphere will drive the liquid into the pipette. When the liquid rises just above the mark on the tube, quickly slip your fore-finger over the top-end as you remove it from your mouth. By carefully raising your fore-finger allow some of the liquid to flow out until the surface is level with the mark. You will find the pipette very useful in transferring small, definite quantities of a liquid from one vessel to another.



Vessels for measuring definite volumes
Left: the measuring flask
Right: the pipette
M = mark

Measuring flasks are made in different sizes to contain large, definite volumes of a liquid i.e. 50, 100, 250, 500 or 1,000 cubic centimetres. On the neck of the flask is a circular mark. When liquid fills the flask up to the mark, the volume of the liquid is as indicated by the number on the body of the flask.

The measuring cylinder and the burette help in obtaining the volume of a given liquid, and also for delivering known quantities of a liquid.

The measuring cylinder is a tall glass jar with a lip and a

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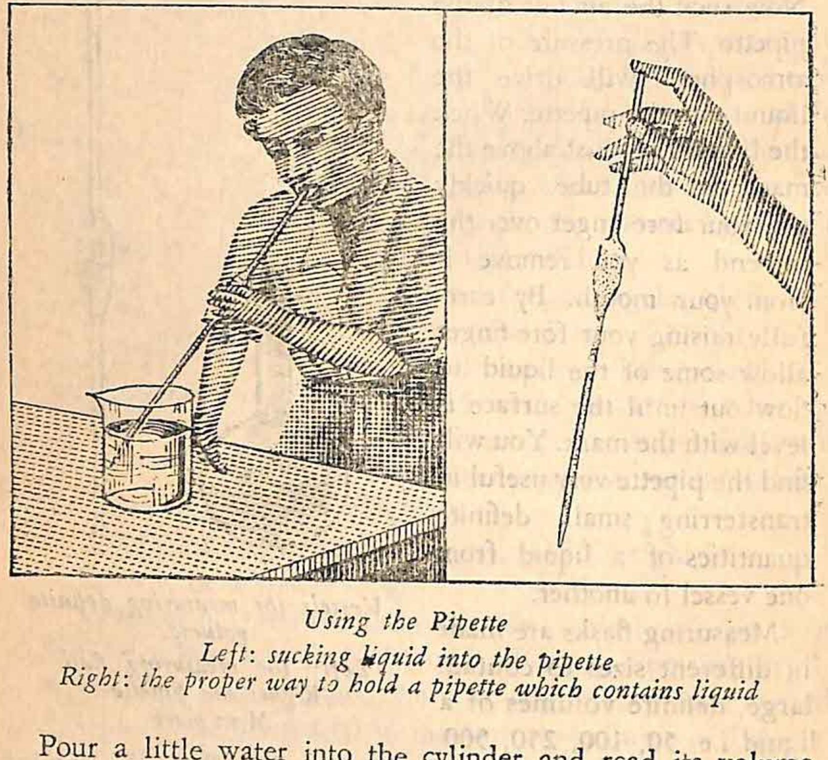
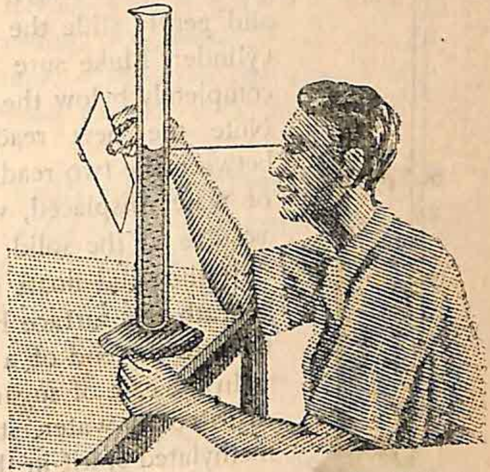
set of graduations along its length. The graduations are in cubic centimetres, and read upwards.



Using the Pipette
Left: sucking liquid into the pipette
Right: the proper way to hold a pipette which contains liquid

Pour a little water into the cylinder and read its volume from the mark at which the top surface of the liquid stands. Note that the surface is curved. To avoid any errors when reading the volume, be sure that your eye is on the same level as the lowest part of the curved surface. If you hold a piece of white paper behind the curve it will enable you to read off the volume accurately.

The burette is a long, narrow graduated tube tapering at the lower end, which is provided with a tap. The graduations are in cubic centimetres and read downwards. By turning the tap on or off, the flow of liquid in the burette can be regulated.

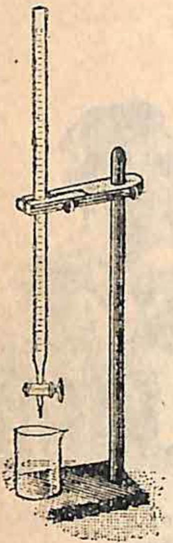


How to read the level of a liquid in a measuring cylinder

Prepare the burette for use by filling it with liquid until the level is well above the 0 mark. Open the tap and allow some of the liquid to run out until the level stands at 0. By doing this the air in the exit tube will be expelled. To deliver 15 cubic centimetres of liquid open the tap until the level falls to the 15 c.c. mark and quickly close the tap. If another 6 cubic centimetres of the liquid is required there is no need to refill the burette — merely open the tap until the level falls to 21 c.c. and then close the tap quickly.

Volumes of Irregular Solids. When a solid is immersed in a liquid there will be a rise in the level of the liquid. This is due to the fact that no two things can occupy the same space at the same time. The solid makes room for itself by displacing its own volume of liquid. Volumes of small irregular solids may be obtained with the help of the measuring cylinder.

Pour some water into the measuring cylinder and read the volume of the water. Now tilt the cylinder and gently slide the given object into the cylinder. Make sure that the object lies completely below the surface of the water. Note the new reading. The difference between the two readings gives the volume of water displaced, which is equal to the volume of the solid.

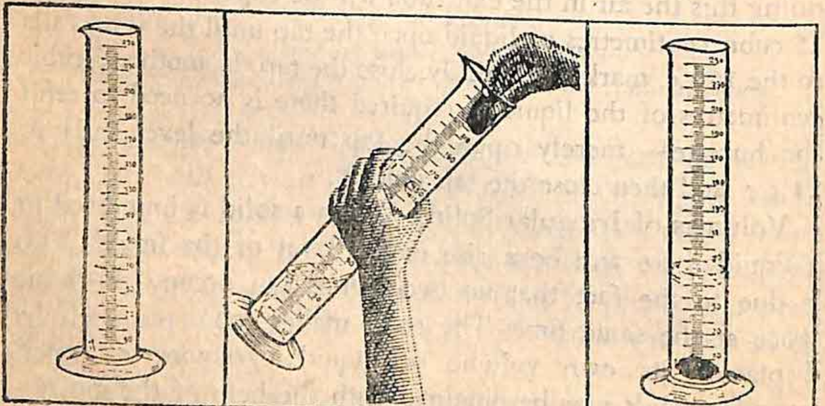


The Burette

If the solid floats it should be pushed beneath the surface by means of a needle fixed to the end of a wooden rod.

In the case of sugar and salt, which both dissolve in water, it is necessary to use methylated spirit in the measuring cylinder to find their volumes.

Volumes of Small Regular Solids. For finding the volume of tiny objects such



Finding the volume of an irregular solid as lead shot, nails, pins and so on, the burette is suitable. Pour some water into the burette and make the reading. Next hold the burette at a slant and carefully drop in a given number of the shot. Note the second reading. The difference between the two readings gives the volume of the given number of lead shot, from which the volume of one lead shot may be calculated.

A scientist must collect accurate information to solve his problems. He experiments carefully and uses special tools to help him calculate how much of certain materials are involved in his problems. In this chapter you have read about a few of the many tools he uses and the proper way in which you may use them.

Things to make and do

A home-made measuring bottle:

Obtain a tall, narrow, glass vessel such as a kerosene-oil bottle and gum a strip of paper along the length of the vessel. Pour in water, five cubic centimetres at a time and make suitable markings on the paper strip. A standard burette will help you to do this. After carefully numbering the markings from the bottom upwards, the measuring bottle you have made will be ready for use.

In and around your home:

1. The space occupied by a solid or liquid is called its volume. The space within any hollow vessel is called its capacity. Use your home-made measuring bottle to find the capacity of a milk bottle, a jam-jar, a tumbler and an ink-bottle. Write your answers in cubic centimetres.

2. A unit called the litre is used for measuring large volumes of a liquid. A litre is equal to 1,000 cubic centimetres. Find how many litres of water you can get into a tub.

3. Find the volume of a brick. To do this, make a mark on the inner surface of a pail. Now find the volume of water required to fill the pail up to this mark. Empty the pail and place the brick in it. Fill the pail again with water up to the mark, and measure the volume of this second amount of water. The difference between the two readings gives the volume of the brick.

For your wall newspaper:

Do three separate drawings to show the difference between an inch, a square inch and a cubic inch.

In your note-book:

1. Find the number of cubic centimetres in one cubic inch.

2. How many (*a*) cu.mm., (*b*) c.c., (*c*) cu.dm. are there in a cu.m.?

3. You have read how the volume of an irregular piece of wood may be obtained by gently pushing the wood beneath the surface of water with a needle. Another way of finding its volume is by attaching it to a metal sinker such as an iron nut. First find the volume of the sinker and then find the volume of the wood and sinker together. Enter your readings into your note-book as follows:

Height of water-level before adding sinker = c.c.
Height of water-level after adding sinker = c.c.
Volume of sinker (water displaced) = c.c.
Height of water-level before adding sinker and wood = c.c.
Height of water-level after adding sinker and wood = c.c.

Volume of sinker and wood (water displaced) = c.c.
Volume of wood = Volume of sinker and wood − Volume of sinker.

Fill in the blanks:

Choose the correct words from this list and use them to fill in the blank spaces: qipette, foot, burette, vessels, surface, regular, space, formulæ, flask, irregular, cylinder, lines, surfaces, volume, area, centimetre.

A plane figure is enclosed by —— and occupies a —— called its ——. A solid figure is enclosed by —— and occupies a —— called its ——. The cubic —— is the unit used to measure volume in the British system. The cubic —— is the unit used to measure volume in the Metric system. Volumes of regular solids are found by the use of ——. Volumes of liquids are found by the use of graduated ——. When definite volumes of a liquid are required the —— and measuring —— are used. The measuring —— and —— help in obtaining the volume of a given liquid and also for delivering known quantities of a liquid. Volumes of small —— solids are obtained with the help of the measuring cylinder. Volumes of small —— solids are obtained with the help of the burette.

4

The Unseen Force that pulls Everything down

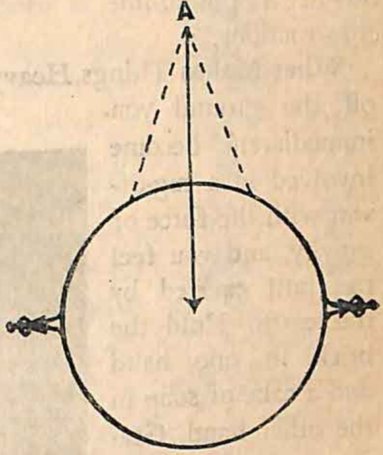
WHY DOES a plate fall to the floor if it slips from your grasp? A ball thrown straight up in the air goes up a few yards and then comes down again. Everything, in fact, falls towards the earth unless it has some support. Have you ever wondered why things fall towards the earth instead of towards the sky? The reason is that the earth pulls everything on it and near it. The force with which the earth pulls things on or near its surface is called the force of gravity.

We cannot see gravity but we know what it does. It is gravity that pulls the raindrops, snowflakes and hailstones down to the earth; makes rivers flow down towards the sea and changes a gentle stream flowing over the edge of a precipice into a raging waterfall. Gravity keeps the atmosphere as a layer around the earth and the ocean in its bed. In fact, if it were not for gravity we and everything else would drop off the earth.

'Up' and 'Down'. You have learnt in Geography that the earth is round. When we think of people on the opposite side of the earth to us, with their heads hanging into space and their feet on the earth it does appear as if they are upside down. What exactly do we mean when we say 'down' and 'up'? Everywhere on the earth 'down' means towards the centre of the earth and 'up' means away from the centre of the earth.

People on the opposite side of the earth to us stand with their feet pointing down and with their heads pointing up, just as we do. It is therefore a mistake to think of people who have their feet on the earth as being upside down.

Hold a ball in front of you and then let it fall. You will notice that it does not drop in a slanting direction but falls straight down. In the drawing the circle represents the earth and the unbroken line the path taken by a falling body. You can prove by measurement that the shortest line from the point A to the circumference would pass through the centre of the circle if produced. All falling bodies are pulled by gravity towards the centre of the earth and drop earthwards by the shortest path.

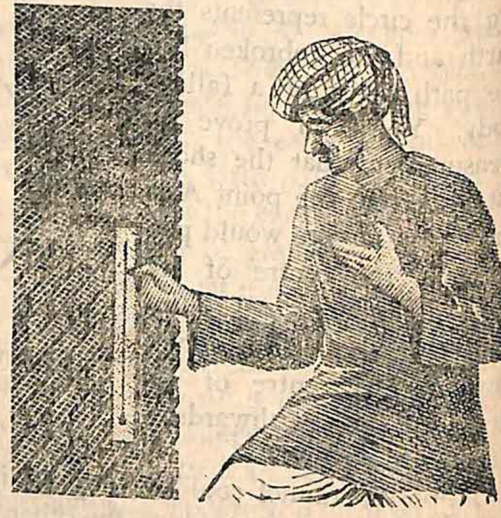


The force of gravity pulls everything towards the centre of the earth

Suppose a tunnel could be dug straight through the centre of the earth from one side to the other. If a ball were dropped down the tunnel what would happen to it? Well, it would fall down until it came to the centre of the earth. At this point it would be going so fast that it would not stop, but continue on its way until it came out at the other end of the tunnel. Then back it would fall and continue to move up and down the tunnel, going a little way less from the centre each time. Finally, it would come to rest at the centre of the earth.

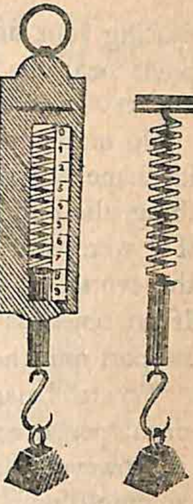
Make a plumb-line and use it to find out which way is straight up and which way is straight down. Fasten a stone to one end of a cord. Now if you hold the other end of the cord, gravity will pull the stone down. The stone points to the centre of the earth and the cord hangs straight up and straight down. A plumb-line is used by builders to make vertical constructions.

What Makes Things Heavy? If you attempt to lift a brick off the ground you immediately become involved in a tug-of-war with the force of gravity, and you feel the pull exerted by the earth. Hold the brick in one hand and a cake of soap in the other hand. Gravity pulls the brick more strongly than it does the soap. Or, in other words, the brick is heavier than the soap. We can find out how much gravity is pulling on an object by hanging it on a spring and then seeing how much the spring stretches. By measuring the amount the spring is pulled out we would be measuring the amount of the pull of gravity on the object i.e. its weight.



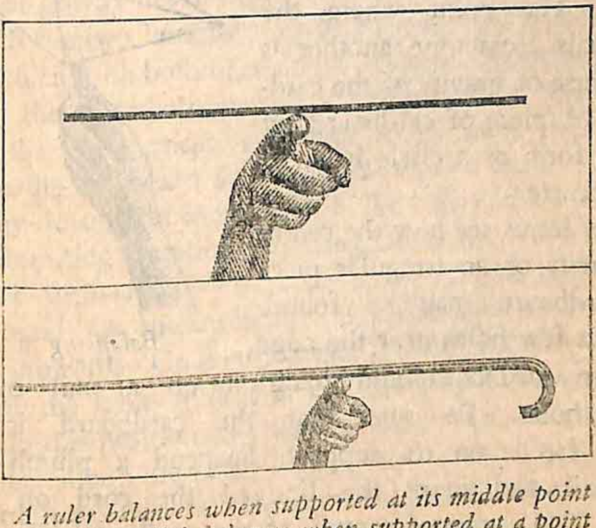
How a builder uses his plumb-line

The Spring Balance. It consists of a spring contained in a metal case. A pointer attached to the lower end of the spring moves along the scale marked on the case and indicates the amount that the spring stretches. Below the pointer is a bar which carries a hook. Objects for weighing are suspended from the hook, and the extension of the spring is then noted.



The Spring Balance

Centre of Gravity. If you have ever tried to balance a ruler horizontally on your finger you will know that it will only remain horizontal when supported at its middle point. Although every part of the ruler goes to make up its total weight, the weight of the ruler as a whole seems to be in the middle. In the case of a walking stick, however, you can only balance it by

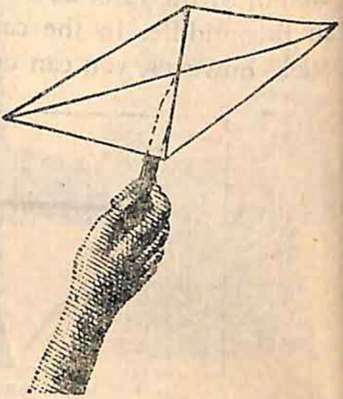


A ruler balances when supported at its middle point
A walking stick balances when supported at a point nearer its handle

placing your finger well away from the middle, for it is at a point near the handle where the entire weight of the stick appears to be concentrated.

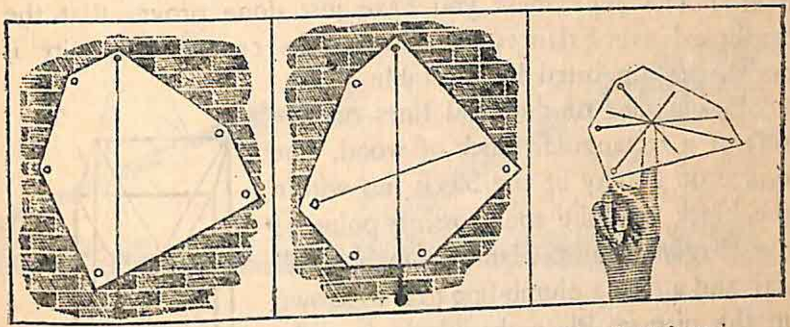
No matter what material an object is made of or whatever its shape, the weight is spread over the object. But with everything, the pull of the earth or the weight of the object acts as if it were concentrated at a certain point. This point is called the centre of weight or the centre of gravity of the object. If an object is to be balanced on a single support, then the support must be vertically below the centre of gravity.

Try to balance a rectangular piece of cardboard on the unsharpened end of a pencil. You will not find it easy. There is, however, a simple method of accomplishing this feat. Draw two diagonal lines on the cardboard. The point where the diagonals cross one another is the centre of gravity of the cardboard. A piece of cardboard cut in the form of a circle balances at its centre.



Balancing a card

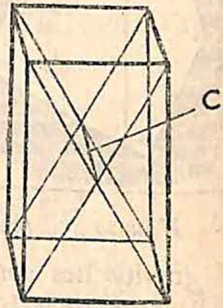
Now let us see how the centre of gravity of an irregular piece of cardboard may be found. Make a few holes near the edge of the cardboard and hang it on a nail by one of these holes. Be sure that the cardboard is able to swing freely on its support. Suspend a plumb-line from the nail and mark the line of the cord on the cardboard. The centre of gravity of the cardboard lies somewher along the vertical line you have drawn. Suspend the cardboar from one of the other holes and draw another vertical line using your plumb-line to guide you as before. Now the centre



How to find the centre of gravity of an irregular-shaped card

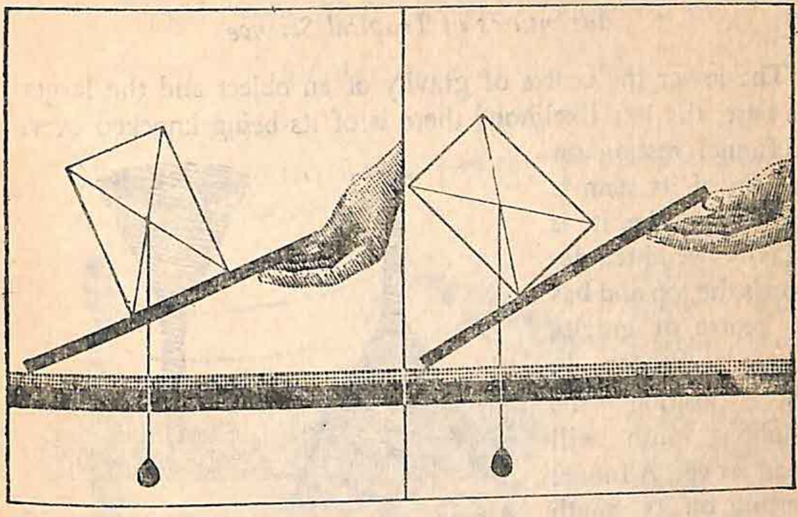
of gravity lies somewhere along this second vertical line as well. Two lines have been drawn on the cardboard and the centre of gravity lies in each. Obviously, it must be at the point at which the two lines meet each other, for at the crossing is a point which is on both lines. If you suspend the cardboard from each of the other holes in turn and draw vertical lines you will notice that the vertical lines meet at the same point. Try to balance the cardboard at this point on your finger tip.

Why do objects topple over? We will find the answer to this interesting question by using the same irregular-shaped piece of cardboard of which the centre of gravity has already been found. Lay the cardboard on a table with its marked side facing upwards. Gradually push the cardboard towards the edge of the table until it is just about to fall over. Hold it firmly in this position and draw a line on the under side of the cardboard along the edge of the table. Change the position of the cardboard and repeat the experiment. Poke a needle through the cardboard at the point where the two lines cross one another. Does this point coincide with the centre of gravity which you have already found on the reverse side of the cardboard? The experiment you have just done proves that the cardboard over-balances the moment its centre of gravity is no longer supported by the table.

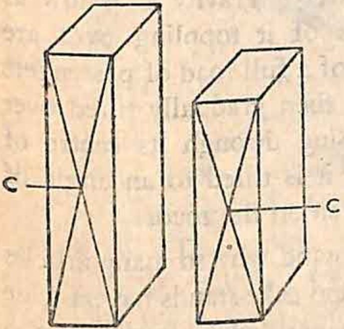


The centre of gravity of this rectangular block of wood is at the point C

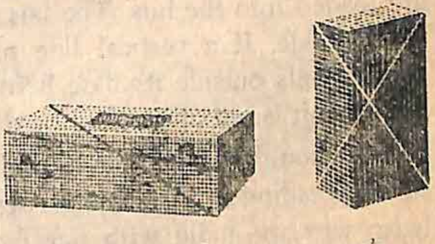
Mark a pair of diagonal lines on one side of a rectangular block of wood. The centre of gravity of the block lies within the block opposite the crossing point of the diagonal lines. Hammer in a small nail and attach a plumb-line to it as shown in the picture. Place the block near the centre of a small plank and tilt it gently. You will notice that as long as the vertical line from the centre of gravity as represented by the cord of the plumb-line lies within the base of the block, the block does not topple over. The moment the vertical line from the centre of gravity falls outside the base of the block, the block topples over. This experiment shows us that an object will be at rest or balanced as long as the vertical line that passes through its centre of gravity remains within the base of the object. If you repeat this experiment with another rectangular block taller than the first but having a base of the same size, you will find that the amount an object has to be tilted before it topples over does not only depend on the area of the base but also on the height of the centre of gravity above the base. A brick stands more securely on its large side than on its end as its centre of gravity in the first position is lower than its centre of gravity in the second position.



The block topples over when the vertical line from its centre of gravity falls outside its base

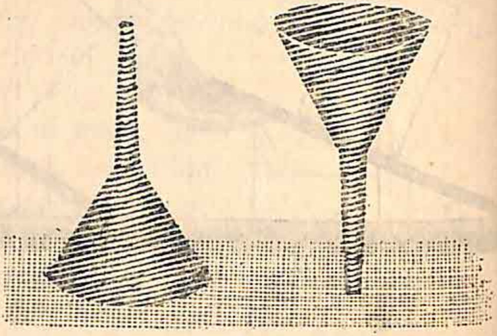


C is a point which is opposite the centre of gravity of each block



A brick stands more securely on its large side than on its end

The lower the centre of gravity of an object and the larger its base, the less likelihood there is of its being knocked over. A funnel resting on the tip of its stem is 'top-heavy' i.e. it is heavily weighted towards the top and has its centre of gravity towards the top. In this position the slightest push will send it over. A funnel resting on its mouth cannot be easily pushed over as it is now heavily weighted towards the base and has its centre of gravity towards the base.



A funnel stands more securely on its mouth than on the tip of its stem

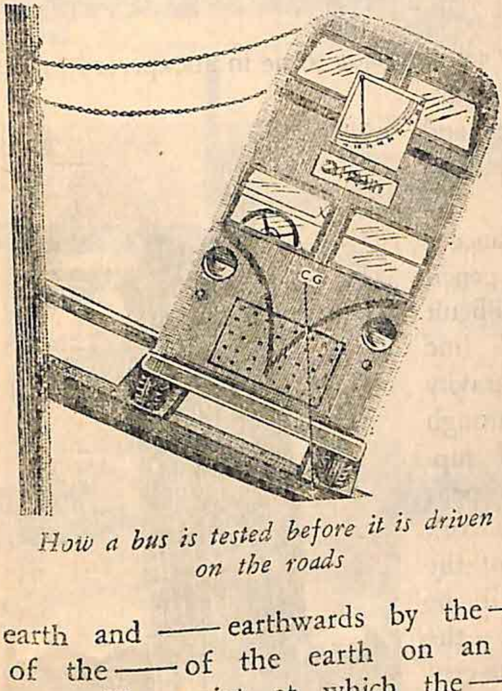
A bus is so designed that its centre of gravity is as low as possible and therefore the chances of it toppling over are small. Sandbags equal to the weight of a full load of passengers are loaded into the bus. The bus is then gradually tilted over on one side. If a vertical line passing through its centre of gravity falls outside its base before it is tilted to an angle of 30° then it is not allowed to be driven on the roads.

You should now be able to understand why so many articles such as reading-lamps, wine-glasses and cake-stands have a wide base; why we stand with our feet apart when standing in a moving bus; why overcrowding is not allowed on the top-deck of a bus; and why the leaning tower of Pisa does not topple over.

Things to make and do

Fill in the blanks:

Choose the correct words from this list and use them to fill in the blank spaces:—



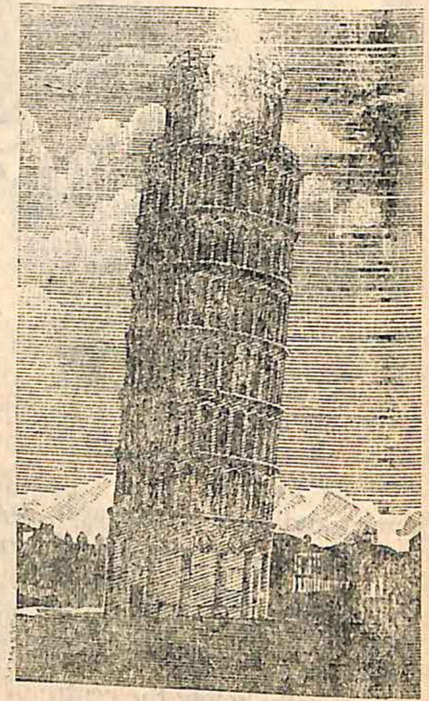
How a bus is tested before it is driven on the roads

Support, pull, vertical, gravity, above, shortest, weight, centre, force, surface, base, height, area, drop, total, topple, below.

The force with which the earth pulls things on or near its —— is called the —— of gravity. All falling bodies are pulled by —— towards the centre of the earth and —— earthwards by the —— path. The amount of the —— of the earth on an object is called its ——. The point at which the —— weight of a body acts is called the —— of gravity of the body. If an object is to be balanced on a single support, then the —— must be vertically below the centre of gravity. When an object hangs freely from a support it comes to rest with its centre of gravity vertically —— the point of support. As long as the —— line from the centre of gravity of an object lies within the —— of the object, the object will not —— over. The amount an object has to be tilted before it topples over does not only depend on the —— of the base but also on the —— of the centre of gravity —— the base.

Tricks and toys:

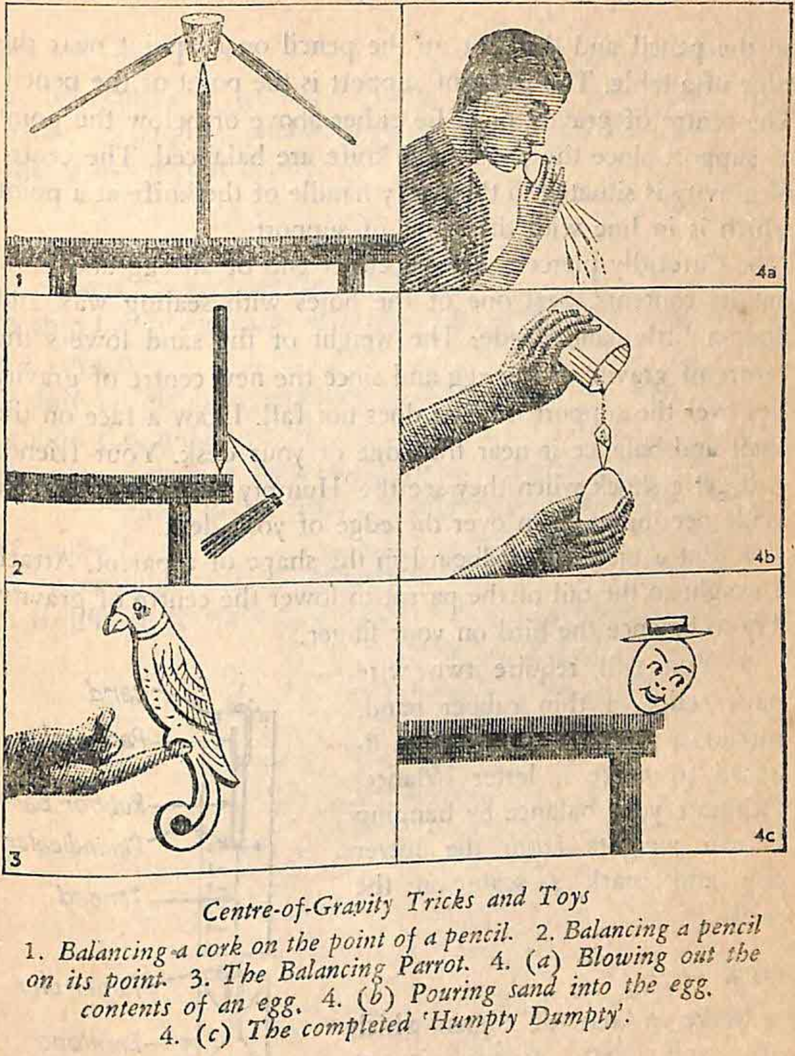
The centre of gravity can be made to lie in unexpected places by the use of heavy substances. Do these tricks and make these toys to puzzle your friends.



The Leaning Tower of Pisa

1. If you try to balance a cork on the point of a pencil you will find it very difficult to keep the vertical line through the centre of gravity of the cork going through such a small point of support. By sticking two pens into either side of the cork the centre of gravity of the balancing objects will be lowered because of the weight of the pens. The centre of gravity is now below the point of support i.e. inside the pencil.

2. A pencil can be made to balance on its point with the help of a pocket knife. Stick the blade of the knife low down



Centre-of-Gravity Tricks and Toys

1. *Balancing a cork on the point of a pencil.* 2. *Balancing a pencil on its point.* 3. *The Balancing Parrot.* 4. (*a*) *Blowing out the contents of an egg.* 4. (*b*) *Pouring sand into the egg.* 4. (*c*) *The completed 'Humpty Dumpty'.*

on the pencil and then set up the pencil on its point near the edge of a table. The point of support is the point of the pencil. The centre of gravity must lie either above or below the point of support since the pencil and knife are balanced. The centre of gravity is situated in the heavy handle of the knife at a point which is in line with the point of support.

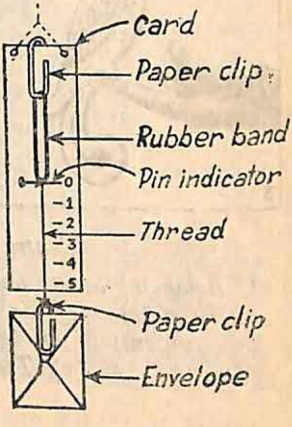
3. Carefully pierce a hole at either end of an egg and blow out its contents. Seal one of the holes with sealing wax and pour a little sand inside. The weight of the sand lowers the centre of gravity of the egg and since the new centre of gravity lies over the support the egg does not fall. Draw a face on the shell and balance it near the edge of your desk. Your friends will get a shock when they see the 'Humpty Dumpty' you have made peering at them over the edge of your desk.

4. Cut a piece of cardboard in the shape of a parrot. Attach a weight to the tail of the parrot to lower the centre of gravity. Try to balance the bird on your finger.

5. You will require two wire paper clips, a thin rubber band, thread, a pin and a strip of cardboard to make a letter balance. Calibrate your balance by hanging known weights from the lower clip and mark a scale on the card.

Outdoors:

Make a list of signs which tell you that gravity is at work.



A letter balance

For your wall newspaper:

Find the centres of gravity of cards shaped in the forms of squares, rectangles, parallelograms, triangles, and circles. Paste the cards on your board.

In your note-book:

Give reasons for each of the following :

1. A ship having no cargo is loaded with iron bars or stones before a voyage.

2. Before an elephant picks up a log of wood he curls his trunk round the middle of the log.

3. A man carrying a heavy suitcase in his left hand leans over to the right and sometimes puts out his right arm to balance himself.

4. A boxer fights with his feet apart.

5. It is difficult to walk on stilts.

5

The Unseen Force that presses on Everything

ALTHOUGH we live at the bottom of a great ocean of ai and depend on it in so many ways we seldom think muc about it. Air is such a common gas that we take it for grante Since it is colourless, we cannot see it, but we can study it b observing its effects. You have learned in Book IV that eve a small amount of air has weight and therefore it exert pressure. We will consider here the enormous pressure of th ocean of air around us and see how it can be measured.

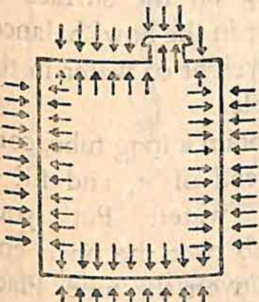
The Pressure of the Atmosphere. Scientists have found tha the ocean of air, called the atmosphere, extends upwards fo more than 200 miles and consists of several layers. These layer lie around the earth in much the same way as several cover might enclose a cricket ball. As you have read in the previou chapter, it is the force of gravity that holds the atmospher to the earth.

Imagine a pile of sponges stacked one on top of the othe The sponge at the bottom is flattened most since it bears th weight of all the other sponges on top of it. Moreover, th sponge at the bottom, being elastic resists the pressure upo it, and exerts its own pressure against the other sponges whic are compressing it. Air, like the sponges, is elastic. The laye of air nearest the earth has to bear the weight of the layer of air above it, consequently it is compressed and since it cannot escape anywhere away from the earth it presses in all directions — downwards, sideways and upwards.

If the air inside a thin-walled vessel did not push outwards as hard as the air on the outside pushed inwards, the vessel would collapse. The pressure of the air is indeed enormous. You will find it hard to believe that the force due to air pressure on a man of average size is about 30,000 pounds. With this great pressure acting on each of us you may well ask why the pressure of the air does not crush us to death? The reason is that there is air inside our bodies.

The sponge at the bottom is compressed the most

The numerous pores and openings in our skin allow air to enter and there is thus free communication between the air inside and the air outside. The pressure of the air inside our bodies counterbalances the pressure of the air outside. Our bodies do not collapse for the same reason that a lump of cotton is not squeezed out of shape by the pressure of the air.



To show why a thin-walled vessel does not collapse

Those of us who have been up in an aeroplane have experienced a popping sensation in our ears. This is explained by the fact that the atmosphere gradually thins out as we rise and the pressure of the air grows less. Consequently the air inside our heads pushes outwards against our ear drums.

Mountaineers find it difficult to climb to the top of a high mountain because there the air is insufficient for them to breathe. As a result they rapidly become exhausted. Also, at the top of a mountain the pressure of the air is less than it is on the plains and since the air in their bodies continues to exert pressure outwards they may bleed from the nose and ears. After bearing low atmospheric pressure for a few days, however, a mountaineer becomes accustomed to it.

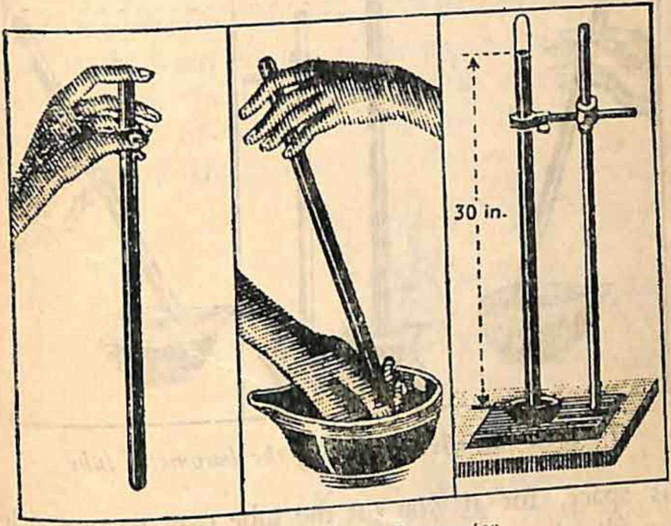
How air pressure holds up liquids. Immerse a tumbler in a bowl of water so that it fills and then carefully invert the tumbler, raising it partly out of the water. You will not have to think long to guess why the water does not fall out of the tumbler. The pressure of the air acting on the surface of water in the bowl balances the weight of water in the tumbler.

Air pressure supports these water columns

Obtain a long tube, cork one end of it, and fill it with water. Put your thumb over the open end and invert the tube. Place the open end in a bowl of water and remove your finger. You will notice that the water column is not lessened Here again it is air pressure that supports the water in the tube The pressure of the air is so great that it can hold up a column of water nearly thirty-four feet high.

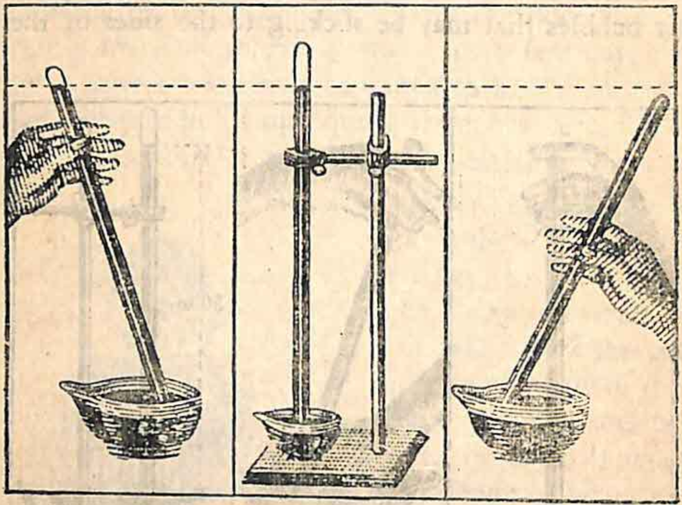
Now let us see what would happen if we repeat this experiment using a liquid which is thirteen and a half times heavier than water.

The Barometer. Take a clean dry glass tube about 34 inches long and closed at one end. Fill the tube with mercury. Remove any air bubbles that may be sticking to the sides of the tube



How to make a Barometer

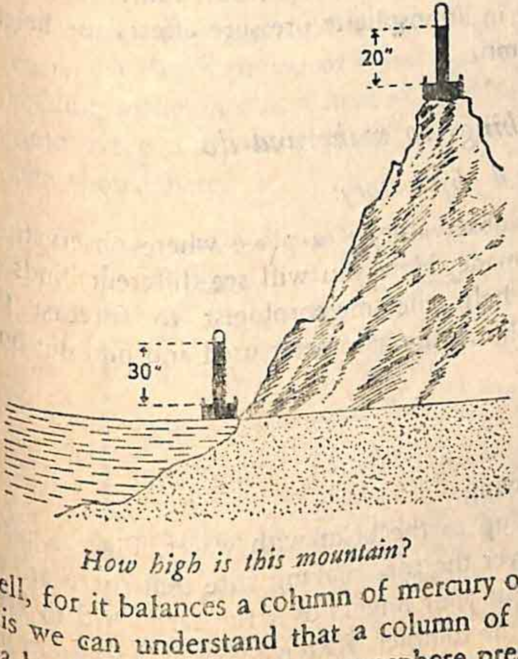
by tapping the tube gently. Place a finger over the open end and, inverting the tube, place this end in a small dish of mercury. When the end of the tube is under the surface of the mercury in the dish remove your finger and notice what happens. You might expect the heavy liquid to fall out of the tube with a flop. Instead it drops a few inches at the top of the tube leaving a space. Since you commenced the experiment with a tube full of mercury and no air was seen to ente the tube, the space above the mercury in the tube cannot be air. What is it then? It is a vacuum — a space containing absolutely nothing. You can easily see that there is nothing



To show the effect of tilting the barometer tube

in this space, for if you tilt the tube over to one side th mercury fills the tube right to the top. As you hold the tub vertically, however, the space appears again. Now, the vacuu at the top of the mercury in the tube, being nothing, ca neither push nor pull the column of mercury, whereas th mercury in the dish has the air pressing on it. The weight o the atmosphere pressing on the surface of the mercury in th dish prevents the mercury from falling any further in the tub If for any reason the atmospheric pressure becomes greate then it presses harder on the surface of the mercury in the dis and up goes the mercury in the tube; but if the atmospheric pressure becomes less then it presses more lightly on the surface of the mercury in the dish and down comes the mercury in the tube. The device you have made is called the Simple Mercury Barometer and can be used to measure the pressure of the atmosphere.

Suppose the tube has a cross-sectional area of one square inch. The distance between the top of the mercury column and the surface of mercury in the dish will be 30 inches at sea level. Then the volume of mercury in the tube is 30 cubic inches. Now since the weight of one cubic inch of mercury is about half a pound, the weight of 30 cubic inches of mercury is about 15 pounds. The pressure of the mercury column on an area of one square inch is therefore about 15 pounds. Hence we know that the pressure of the atmosphere must be about 15 pounds to the square inch as well, for it balances a column of mercury of that weight. From this we can understand that a column of air extending from sea level to the top of the atmosphere presses down on everything with a force equal to about 15 pounds per square inch.



How high is this mountain?

You have already read that as we go higher the pressure of the atmosphere decreases. If a barometer is taken to the top of a tall mountain a drop in the level of mercury will be observed. For every thousand feet we ascend, the column of mercury falls approximately one inch. By measuring the height of the mercury column we are able to get some idea of the height of the mountain.

There is a very close connection between the pressure of the atmosphere and the weather. Because of this a barometer is often used for forecasting the weather. Air which is dry is heavier than air which is moist. The pressure of the atmosphere is greater on fine dry days than it is on dull rainy days. This increase or decrease in atmospheric pressure affects the height of the mercury column.

Things to make and do

Visit a meteorological observatory:

A meteorological observatory is a place where observations of the weather are made. Here you will see different kinds of instruments which help the meteorologist to forecast the weather. Ask to be shown the barometer used and find out how it works.

In your note-book:

Explain the following:

1. Fill a tumbler up to the brim with water. Place a piece of thin cardboard over the top, making sure that there are no air bubbles below. Put your fingers over the cardboard to keep it steady and invert the tumbler. Remove your fingers from the cardboard. The air pressure acting upwards on the cardboard

keeps the water in the tumbler. Carefully pierce a hole in the cardboard and note what happens.

2. A balloon filled with air bursts when taken up in the atmosphere.

3. If a barometer is taken down the shaft of a mine the level of mercury in the tube rises.

4. If air is allowed to enter the vacuum of a barometer the level of mercury in the tube drops.

5. Suppose you bored a tiny hole through the glass at the top of the barometer tube. What result would you expect?

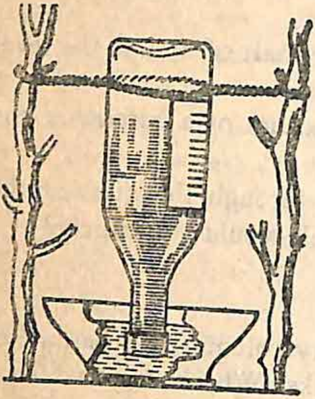
For your wall newspaper:

Measure the height of the mercury column in a barometer every day for a period of three weeks. Whenever you take a reading make an observation of the weather conditions at that time. Keep a record of your observations in a table like the one shown here.

Date	Barometric Reading	Weather Condition
10th June	29½ in.	Fair
11th June	29¼ in.	Cloudy
12th June	29 in.	Raining

A home-made barometer:

Obtain a bottle with a narrow neck to make your own barometer. Fill the bottle partly with water and invert it over a shallow trough of water so that the lower portion of its neck is immersed in the water. Support the bottle as shown in the picture.



A home-made barometer.

When the humidity of the air outside is high, the air becomes lighter, and the level of water in the bottle will fall. If, however, the air outside is dry it becomes heavier and the level of water in bottle will rise. The variations in atmospheric pressure can be recorded approximately on a strip of paper gummed to the outside surface of the bottle.

Fill in the blanks:

Choose the correct words from this list and use them to fill in the blank spaces:

directions. airmen, weight, thirty, ocean, barometer, decreases, atmosphere, meteorologists, mercury, mountaineers, down, water, compressed, thirty-four.

The earth is surrounded by an —— of air called the —— which consists of several layers. Each layer presses —— on the layer below it. The layer of air in which we live bears the —— of the rest of the atmosphere. It is therefore —— and as a result presses in all ——.

We can measure the pressure of the atmosphere by means of a ——. At sea level the atmospheric pressure is enough to hold up a column of —— to a height of —— inches and a column of —— to a height of —— feet. As we ascend, the atmospheric pressure ——. Barometers are used by —— and —— to enable them to know how high they are and also by —— to help them forecast the weather.

6

The Measurement of Temperature

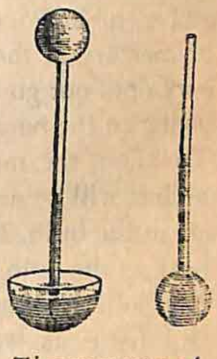
THE temperature of a substance is a measure of its 'hotness' or 'coldness'. Temperature does not tell us the amount of heat contained in a substance, but it does tell us how hot or cold a substance is. A healthy man weighing 180 pounds has twice the amount of heat in his body as compared with a healthy boy weighing 90 pounds, but both man and boy have the same temperature.

We usually rely on our sense of touch to tell us whether a substance is hot or cold. If we put a hand in hot water heat flows from the water to the hand and produces a sensation of warmth. If, however, we place a hand in cold water heat flows from the hand to the water and produces a sensation of cold. When two substances are in contact with one another heat flows from the substance at the higher temperature to the substance at the lower temperature, until a common level of temperature is reached.

Our sense of touch is, as a rule, quite reliable for comparing temperatures, but it can sometimes prove misleading. Put one hand in hot water and the other in cold water for a few moments. Now put both hands together in warm water. The hand which was in hot water will give you the impression that it is now in cold water, whilst the hand which was in cold water will give you the impression that it is now in hot water. In this experiment the 'hot' hand loses heat the moment it is placed in warm water and therefore feels cold; the 'cold' hand gains heat when it is placed in warm water and so feels hot. Besides being unreliable under certain conditions, our sense of touch does not help us to measure temperature or change of temperature accurately.

Thermometers. An instrument used for the measurement of temperature is called a thermometer. This instrument makes use of the fact that substances expand when heated and contract when cooled.

The first thermometer consisted of a glass bulb with a long stem inverted in a dish of coloured water. The air inside the bulb was warmed so that a little was expelled. When the air in the bulb cooled, a little water rose up the stem to take the place of the air that had been expelled. If the day was warm the air in the bulb would expand and the level of water in the tube would sink. On a cold day the air in the bulb would contract and the level of water in the tube would rise. This thermometer had two serious disadvantages. Firstly, as the water in the dish evaporated the surface lowered and brought down the column of water in the stem. Secondly, changes in atmospheric pressure affected the height of the water column.



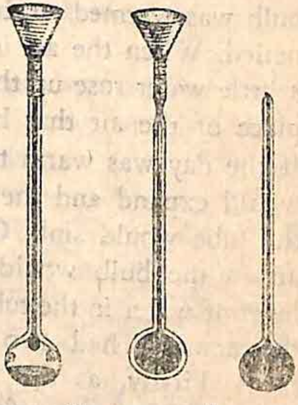
Thermometers of long ago

A thermometer consisting of a bulb and tube, with the bulb and part of the tube filled with coloured water was another of the instruments used many years ago to measure temperature.

On warm days the level of water in the tube would rise and on cold days the reverse would happen. This thermometer proved unsatisfactory as well, since the water evaporated in the open tube.

The thermometer widely used today is the mercury thermometer. The mercury is in a glass bulb which leads to a thick-walled, narrow tube sealed at its upper end. It is essential to remove all the air from the space above the mercury for unless this is done the liquid in expanding to the top of the tube would compress the remaining air in the tube and burst the bulb.

Construction of a Thermometer. Select a tube of uniform and narrow bore having a bulb at one end. Fit a funnel to the open end with the help of a short rubber tube. Pour a small quantity of mercury in the funnel. The mercury does not go down into the bulb owing to the bore being too narrow. To allow the mercury to enter the bulb it will be necessary to expel the air in the bulb. This can be done by heating the bulb, for when the air in the bulb is heated it will expand and force its way out through the mercury in the funnel. When the bulb is allowed to cool, the air inside contracts, and since the pressure inside is now reduced, the atmospheric pressure acting on the surface of the mercury in the funnel forces some mercury down the tube to take the place of the expelled air. Repeat this procedure of heating and cooling several times until mercury fills the bulb and rises a short distance up the tube. Now boil the



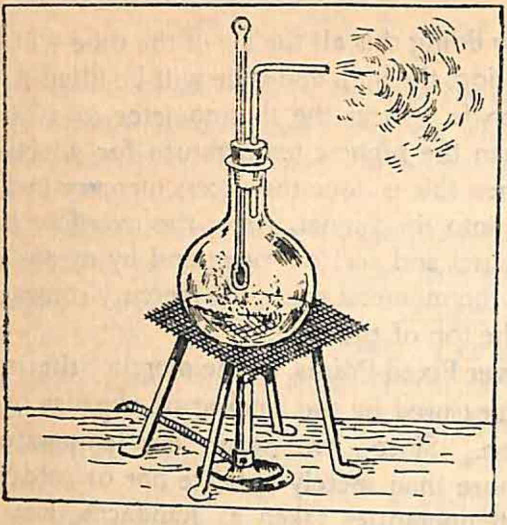
How to make a Thermometer

mercury in the bulb. By doing this all the air in the tube will be driven out, and on cooling, the bulb and tube will be filled with mercury. The next step is to heat the thermometer to a little higher temperature than the highest temperature for which it is to be employed. When this is done the excess mercury in the thermometer will run into the funnel. After the overflow has ceased, remove the funnel and seal the open end by means of a strong flame. As the thermometer cools, the mercury contracts leaving a vacuum at the top of the tube.

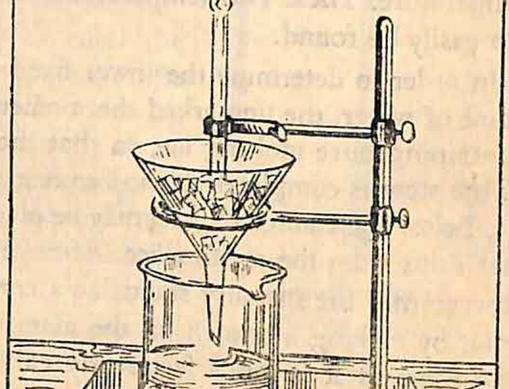
The Upper and Lower Fixed Points. In the mercury thermometer, temperature is measured by the amount of expansion of the mercury in the tube. Since we want our temperature gauge to do a little more than merely indicate hot or cold, we need certain definite temperatures taken as standards, just as we needed standards for the measurement of length, area and volume. In the measurement of temperature, the freezing and boiling points of water have been fixed as the standards of temperature. These two temperatures are always the same and can easily be found.

In order to determine the lower fixed point, i.e. the freezing point of water, the unmarked thermometer is put into a funnel containing pure melting ice, so that the bulb and lower part of the stem is completely buried amongst the pieces of crushed ice. Below the funnel a vessel may be placed to collect the water that drips from the melting ice. After several minutes you will observe that the mercury stands at a constant level. Mark this point by making a scratch on the glass. It is the melting-point of ice or, as it is more frequently called, the freezing point of water.

The upper fixed point, i.e. the boiling point of water may be obtained as follows. Pour a little water into a flask and fit it



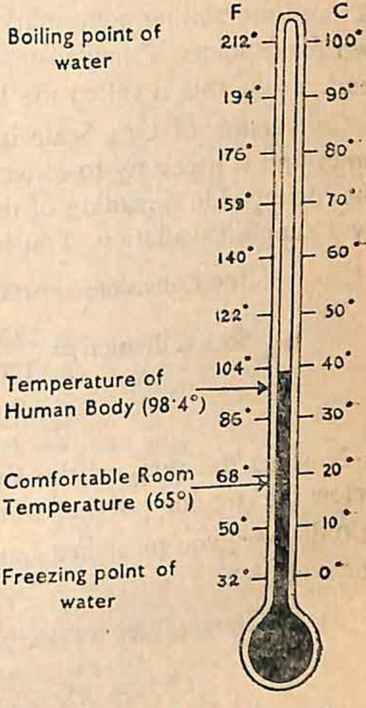
Finding the upper fixed point



Finding the lower fixed point

with a two-holed stopper. Insert the thermometer which was used before through one hole of the stopper, so that the bulb is a little above the surface of water in the flask. Through the second hole of the stopper insert a bent tube. On boiling the water in the flask, steam will circulate round the lower part of the thermometer and then escape by the side tube. The temperature of the steam is the same as that of the boiling water. After a while the mercury takes up a stationary position. Mark this point as before.

If you repeat this experiment on the top of a high mountain you will obtain a result slightly less than the normal boiling point. This is because the boiling point of water depends on the atmospheric pressure at the place where it is measured. The boiling point of water is, therefore, defined as the temperature at which pure water boils under standard atmospheric pressure i.e. a pressure corresponding to a barometer height of about 30 in. or 76 cm. of mercury.



The Centigrade (C) and Fahrenheit (F) scales as compared with each other

Thermometer Scales. Having determined the two fixed points we next put a scale on the stem of the thermometer. This is done by dividing the space between the two fixed points into a number of units called degrees written as °.

There are different ways of dividing the space between the two fixed points. In one kind of thermometer the space is divided into 100 equal parts. Here the freezing point is marked 0° and the boiling point is marked 100°. The thermometer with this simple arrangement is called the Centigrade thermometer. This thermometer is the one generally used for all scientific purposes.

Another kind of thermometer has the freezing point marked 32° and the boiling point marked 212°. The space between the two fixed points is divided into 180 divisions. A thermometer marked like this is called the Fahrenheit thermometer.

Conversion of One Scale into the Other. You will sometimes find it necessary to convert the reading on one scale into the corresponding reading of the other scale. This may be done by a simple calculation. You have read that,

$$100 \text{ C divisions} = 180 \text{ F divisions}$$

$$\text{So 1 C division} = \frac{180}{100} \text{ F divisions}$$

$$= \frac{9}{5} \text{ F divisions}$$

Now as the zero on the Fahrenheit scale is 32 F degrees below the freezing point of water which on the Centigrade scale is 0 degrees, you must first multiply the C reading by $\frac{9}{5}$ and then add 32.

Thus a temperature of

$$15°\text{C} = 15 \times \frac{9}{5} + 32 \text{ or } 59°\text{F}.$$

To change a Fahrenheit reading to the corresponding Centigrade reading you must remember that,

$$180 \text{ F divisions} = 100 \text{ C divisions}$$

$$\text{So 1 F division} = \frac{100}{180} \text{ C divisions}$$

$$= \frac{5}{9} \text{ C divisions}$$

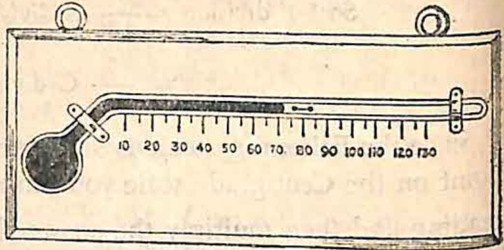
Since the Fahrenheit scale is 32 degrees ahead of the freezing point on the Centigrade scale you must subtract 32 from the F reading and then multiply the answer by $\frac{5}{9}$.

Thus a temperature of 50°F = $(50 - 32)\ \frac{5}{9}$ or 10°C.

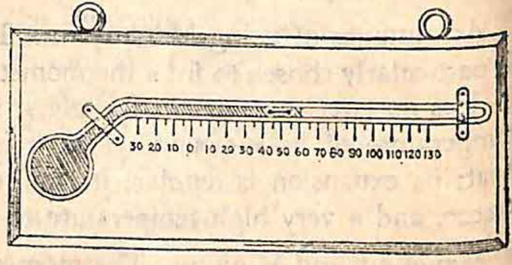
Advantages of using Mercury in a Thermometer. Mercury is particularly chosen to fill a thermometer because it is opaque; it does not wet the sides of the glass; it quickly takes up the temperature of its surroundings as it is a good conductor of heat; its expansion is regular; it requires considerable cold to freeze, and a very high temperature to boil.

Maximum and Minimum Thermometers. In meteorological observations it is necessary to record the highest and lowest temperatures of the air for every period of 24 hours. It would be inconvenient to use an ordinary thermometer for such a purpose as it would be necessary to observe it continually, which is impracticable. Certain thermometers have been specially designed to overcome this difficulty.

The maximum thermometer is merely an ordinary thermometer fixed in a horizontal position to a board. In the bore of the thermometer, beyond the mercury column is a dumb-bell-shaped index made of steel. When the temperature rises, the mercury expands and pushes the index forward. When the temperature falls, the mercury contracts leaving the index behind. The end of the index nearest the mercury gives the maximum temperature reached during a certain period of time. The thermometer is re-set by sliding the index back to the end of the mercury column with a magnet.



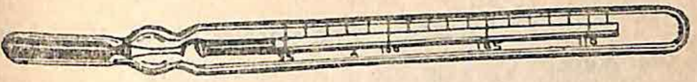
The Maximum F Thermometer



The Minimum F Thermometer

The minimum thermometer is filled with alcohol and fixed in a horizontal position to a board. The dumb-bell-shaped index is made of black glass and is immersed in the alcohol column. When the temperature falls, the alcohol contracts and the surface of the alcohol column drags the index back to the bulb with it. When the temperature rises, the alcohol expands and flows past the index leaving it behind. The end of the index away from the bulb indicates the minimum temperature reached during a certain period of time. The thermometer is re-set by holding it at a slant with the bulb uppermost, thus allowing the index to slide along in the alcohol until it is stopped by the surface of the alcohol.

The Clinical Thermometer. The thermometer with which we are all familiar is the one used by the doctor to take our temperature. It is called the Clinical thermometer. Since the doctor only requires it for testing the temperature of the human body the scale is graduated between 95°F and 110°F, which is as cold or hot as a human being can be. Each degree is divided



The Clinical Thermometer

into five equal parts because even small variations in the temperature of a patient are of great importance. The bulb of the thermometer is small, so that it may quickly reach the temperature of the patient's body. The bore of the thermometer is exceptionally fine and has a kink in it. When the mercury is heated the great force of its expansion pushes it past the kink. As the thermometer is removed from the heat of the patient's body and comes in contact with the cooler air, the mercury contracts. The portion of the mercury below the kink retreats into the bulb whilst the portion of the mercury above the kink stays where it is, as it cannot squeeze its way back through the kink. The thermometer may now be kept until the arrival of the doctor. Once the reading has been taken the thermometer is re-set by bringing the mercury in the bore back to the bulb with a jerk.

A person in good health has a temperature of 98.4°F and there is a mark on the thermometer at this point. A temperature of over 100° F indicates fever and if the thermometer registers over 105° F it means that the patient is dangerously ill.

Things to make and do

Outdoors:

In certain public places you will see thermometers which contain a pink liquid. Write a description of such a thermometer

In your note-book:

1. Give reasons why water is an unsatisfactory liquid for use in thermometers.

2(*a*). The normal blood temperatures of three animals are: Horse: 100°F, Sheep: 104°F and Fowl: 107°F. Convert these temperatures to the corresponding temperatures on the Centigrade scale.

(*b*) Choose any three temperatures given in the weather report of a newspaper and convert them to the corresponding temperatures on the Fahrenheit scale.

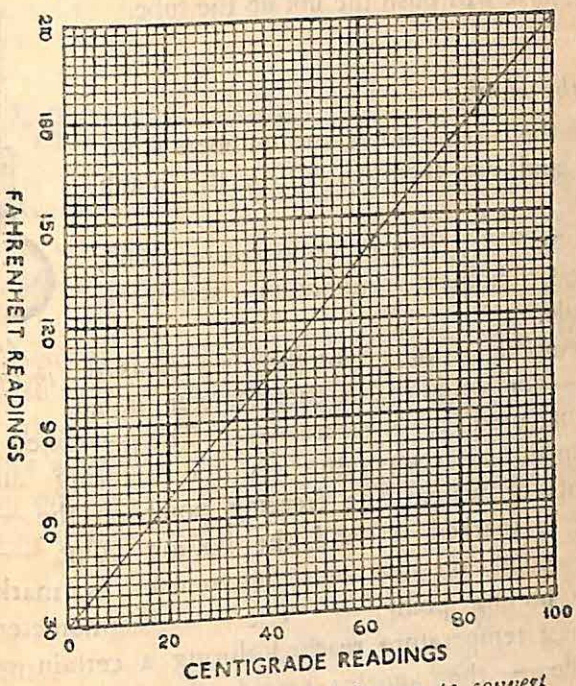
3. A little girl once cleaned a clinical thermometer in boiling water. Explain why her mother found the thermometer useless.

For your wall newspaper:

The conversion of temperatures from one scale to another becomes an easy matter once you have prepared a graph which compares the two scales.

Fill some water in a beaker and heat it nearly to boiling-point. Allow the water to cool. Stir the water as it cools and read its temperature using both Centigrade and Fahrenheit thermometers. Add a little cold water, stir well and read the thermometers as before. Repeat this process, until you have obtained twelve pairs of readings. Plot the points for corresponding readings on a sheet of graph paper, as shown.

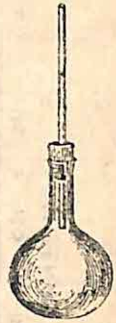
To convert a Fahrenheit temperature to the corresponding Centigrade temperature draw a horizontal line through the given reading on the Fahrenheit axis, and a vertical line through the point where this line cuts the graph. The point where the vertical line cuts the Centigrade axis gives the corresponding reading on the Centigrade scale. Reverse the above procedure to convert Centigrade temperatures to Fahrenheit temperatures.



A graph which will help you to convert temperatures from one scale to the other

An air thermometer:

You can easily construct an air thermometer by fitting a flask with a cork and a glass tube. Before you fix on the cork suck a drop of ink into the tube. You will find that the air in the flask becomes quite warm if you hold the flask in your hands or merely breathe on it. The expansion of the air in the flask will push the ink up the tube.



An air thermometer

Fill in the blanks:

Choose the correct words and numbers from this list and use them to fill in the blank spaces:

maximum, 212°, clinical, temperature, 100°, Fahrenheit, 'hotness', minimum, standards, Centigrade.

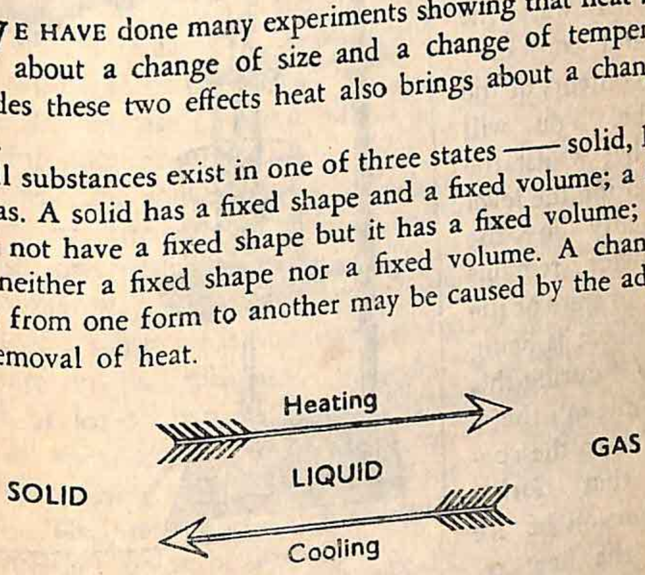
The temperature of a substance is a measure of its —— or 'coldness'. A thermometer is an instrument used to measure ——. The —— fixed in the measurement of temperature is the freezing and boiling points of water. The freezing point on the —— thermometer is marked 0° and the boiling point ——. The freezing point on the —— thermometer is marked 32° and the boiling point ——. The —— thermometer records the highest temperature reached during a certain period of time. The ——thermometer records the lowest temperature reached during a certain period of time. The —— thermometer records the temperature of the human body.

7

Change of State

WE HAVE done many experiments showing that heat brings about a change of size and a change of temperature. Besides these two effects heat also brings about a change of state.

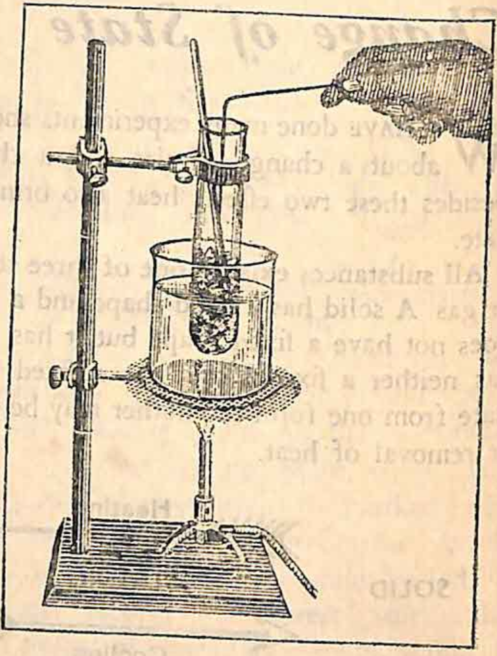
All substances exist in one of three states — solid, liquid or gas. A solid has a fixed shape and a fixed volume; a liquid does not have a fixed shape but it has a fixed volume; a gas has neither a fixed shape nor a fixed volume. A change of state from one form to another may be caused by the addition or removal of heat.



We are all familiar with the three states of water. In the solid form it is ice, in the liquid form it is water and in the gaseous form it is steam. We know from everyday experience that if ice is to be changed to water heat must be applied, and if water is to be changed to ice the water must be cooled.

Melting point. The change of a substance from the solid state to the liquid state is called melting and the temperature at which the change takes place is known as the melting point of the substance.

Fill half a test tube with some pieces of pure ice and insert a thermometer, so that the bulb is completely surrounded by the pieces of crushed ice. Stand the test tube in a beaker of water and note the temperature. Gently warm the water and constantly stir the contents of the test tube. You will notice that whilst the ice is melting, the level of mercury in the thermometer remains constant in spite of the fact that heat is being added to it during this time. We can therefore come to the conclusion that during the conversion of ice to water the heat received is used to bring about a change of state. Once all the ice has changed to water the mercury begins to rise.



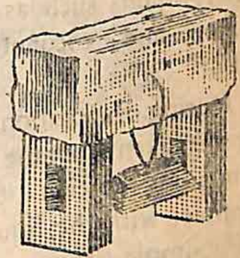
The temperature at which ice melts remains the same until all the ice has changed to water

The melting point of a substance is lowered by the presence of dissolved substances in it. Repeat the last experiment adding some salt to the ice. The presence of the salt lowers the melting point of the ice. Further repetitions of the experiment with the addition of more salt each time will result in the corresponding decrease in the melting point.

Nearly fill a test tube with pure water[*] and suspend a thermometer in the water. Stand the test tube in a beaker containing a mixture of salt and ice. Such a mixture is called a freezing mixture. Stir the water continually and note the temperature at which it freezes. While the water solidifies its temperature remains unaltered. If you compare this temperature with that of the melting point of ice you will find it the same. In the case of many substances, the melting point and freezing point are the same.

Repeat the above experiment using a weak salt solution instead of pure water. You will find that the freezing point is also lowered by the presence of dissolved substances.

Another way of lowering the melting point of a substance is by increasing the pressure on the substance. Support a block of ice on two bricks and pass a loop of thin strong wire round the ice. Attach a heavy weight to the wire as shown. The pressure of the wire lowers the melting point of ice and the ice directly under the wire melts, allowing the wire to press downwards. The water which forms flows round the wire and being free from pressure and surrounded by ice, refreezes above the wire.



The wire passes through the block of ice without cutting it in half

Evaporation. The change of a substance from the liquid to the vapour state is called evaporation. This change of the liquid to vapour is gradual and takes place only at the surface of the liquid.

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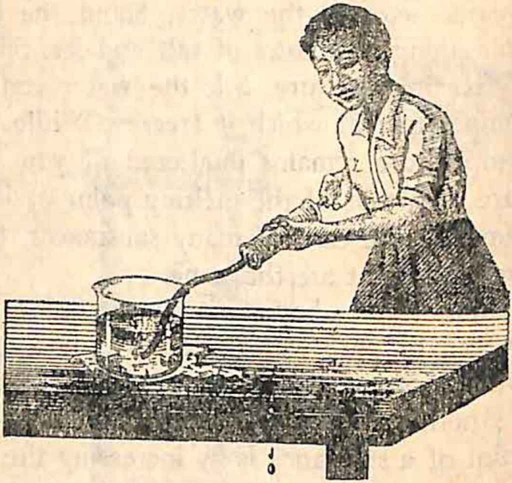
[*] i.e. distilled water

A liquid evaporates quickly if its surroundings are at a high temperature, the atmosphere is dry, the area of the exposed surface is large and there is a breeze to assist in the removal of the vapour as it is formed.

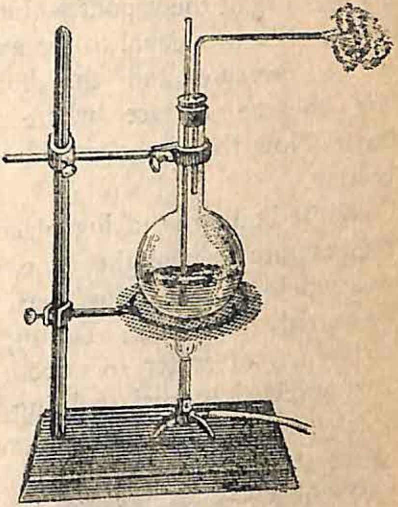
Some liquids such as ether and methylated spirit evaporate more readily than other liquids such as water and coconut oil.



By rapidly evaporating the ether in the beaker the water beneath the beaker freezes

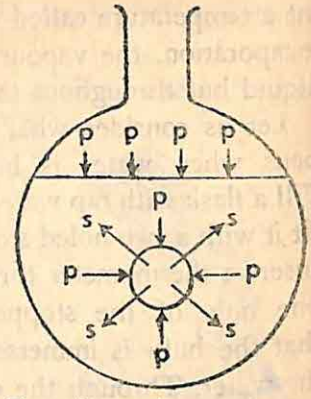
During evaporation heat is taken from the remaining portion of the liquid and from the substance in contact with the liquid. You can easily prove this by means of a simple experiment. Pour some water on a table and put an empty beaker on it. Next, pour some ether in the beaker and blow a stream of air through the ether with the help of a football pump connected to a rubber tube. After the ether has evaporated try removing the beaker from the table. You will find that the beaker is now stuck to the table. When the ether evaporated it took heat away from the bottom of the beaker to such an extent that the water beneath the beaker froze.

Boiling. Boiling is the rapid conversion of a liquid to vapour at a temperature called the boiling point of the liquid. Unlike evaporation, the vapour is formed not at the surface of the liquid but throughout the body of the liquid.



The temperature at which water boils remains the same until all the water has changed to steam

Let us consider what happens when water is boiled. Fill a flask with tap water and fit it with a two-holed stopper Insert a thermometer through one hole of the stopper so that the bulb is immersed in the water. Through the other hole of the stopper insert a bent tube. Heat the water in the flask over a strong flame. Soon you will observe bubbles forming within the liquid and eventually rising to the surface. These are bubbles of air which were dissolved in the water but are expelled from the water when it is heated. The next sign to look for is a misty vapour forming on the surface of the water. The misty vapour is caused by a small amount of water evaporating from the surface, meeting the cool air in the flask and condensing to form a mist of tiny droplets of water. As the water continues to receive heat more bubbles are formed within the liquid. These bubbles contain very hot water vapour called steam, which is formed inside the body of the liquid. If the pressure of the vapour within a bubble is strong enough to withstand the pressure of the atmosphere acting on the surface



To show the pressure exerted on and by a bubble of steam
p. pressure of atmosphere
s. pressure of steam

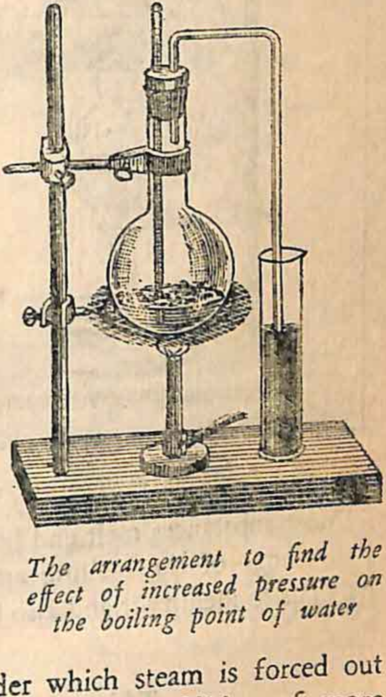
of the liquid it will be able to rise. The first few bubbles are crushed out of existence by the atmospheric pressure. But as the temperature rises the pressure of the vapour within the bubbles becomes equal to the atmospheric pressure and the bubbles rise to the surface where they burst. Now the water is said to be boiling.

While boiling is taking place the temperature remains the same, until the whole of the liquid has been converted to vapour. During the conversion of water to vapour the heat received is used to bring about a change of state.

If you had used pure water for the experiment described above, the flask would be clean and dry at the end of the experiment. The presence of dissolved substances in a liquid raises the boiling point of the liquid. Repeat the same experiment adding some salt to the water. You will find that the boiling point is raised. Further repetitions of the experiment with the addition of more salt each time, will result in the corresponding increase of the boiling point.

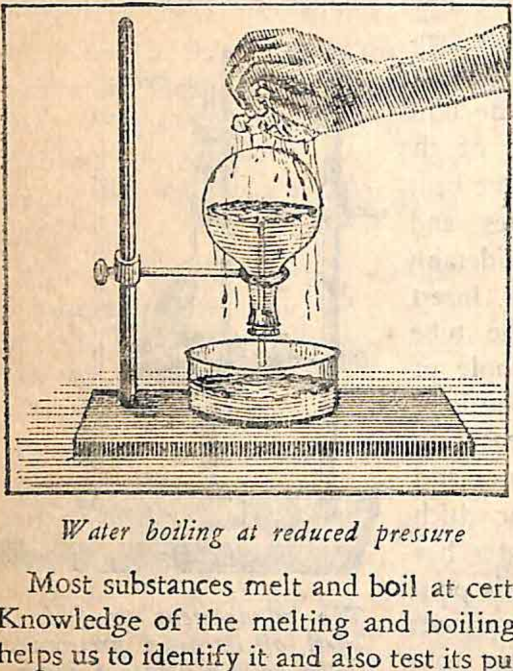
In Chapter Six the boiling point of water was defined as the temperature at which pure water boils under standard atmospheric pressure. We have just seen why it is necessary to use pure water when finding its boiling point. Unless pure water is available it is best to keep the bulb of the thermometer above the surface of water in the flask when determining its boiling point, for in most cases ordinary tap water contains dissolved impurities. Now let us see how alterations in the pressure above the surface of a liquid affects the boiling point of a liquid.

Fit a flask with a two-holed stopper. Pour some pure water in the flask and insert a thermometer through one hole of the stopper so that the bulb is below the surface of the water. Take a glass tube bent twice at right angles and having one arm considerably shorter than the other. Insert the short arm of the tube through the second hole of the stopper and put the long arm into an empty measuring cylinder. Heat the water and note the temperature at which it boils. After the water has been boiling for a while,pour some mercury into the cylinder so that the steam issuing from the tube will bubble through the mercury. The pressure under which steam is forced out of the flask is now increased. With the addition of more mercury in the cylinder the pressure will be further increased and this will be shown in the corresponding rise of the boiling point.



The arrangement to find the effect of increased pressure on the boiling point of water

Take a round bottomed flask and half-fill it with water. Heat the flask and as soon as the water boils freely, quickly insert a cork fitted with a thermometer. The flask now contains water and vapour. Since there is no air in the flask, there is no air pressure acting on the surface of the water. There is, however, the pressure of the vapour acting on the water surface. Invert the flask and cool it by holding it under a stream of water. Some of the vapour in the flask will condense and there will now be less vapour pressing on the surface. This decrease in pressure results in the water boiling at a temperature below its normal boiling point.



Water boiling at reduced pressure

Most substances melt and boil at certain fixed temperatures. Knowledge of the melting and boiling point of a substance helps us to identify it and also test its purity.

Things to make and do

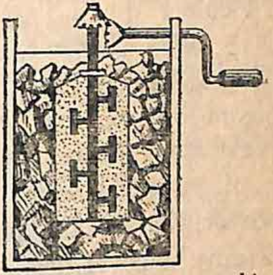
Outdoors:

Look out for these practical applications of the facts given in this chapter.

Melting point:

1. A domestic ice-cream making machine has its inner

compartment surrounded by a freezing mixture. The ingredients for the making of ice-cream are placed in the inner compartment and then churned. When the temperature of the ingredients drops below 0°C they freeze.



Ice-cream making machine

2. Many different kinds of foodstuffs are preserved in a freezing mixture.

3. If you spend the winter at a hill station you will notice that when a rickshaw passes over a snow covered road the increased pressure lowers the melting point of snow from 0°C to just a little less. Consequently some of the snow melts. Once the rickshaw has passed on its way and the pressure is removed the melted snow freezes to ice.

4. A snowball is made by pressing snow between the hands. The pressure of the hands lowers the melting point of the snow and some of it melts. When the pressure on the snow is released the water formed freezes, binding the snowball together. If the temperature is far below 0°C the pressure of the hands is insufficient to melt the snow. Snowballs can only be made with snow which is a few degrees below the melting point.

Evaporation:

1. During the hot summer months water used for drinking purposes is stored in porous earthen pitchers. Water continually oozes out of the sides of the pitcher and evaporates. This results in heat being taken away from the pitcher and the consequent cooling of water in the pitcher.

2. We perspire more in the summer than in the winter. As

the perspiration comes out on to our skin it evaporates and removes heat from our bodies, thereby producing a sensation of cold.

3. Wet *khus-khus* screens are hung near doors and windows during the hot weather. Water is sprinkled on these screens from time to time. The evaporation of the water takes away the heat from the air in the room thus causing a cooling effect.

4. A metal water bottle is usually covered with a canvas cover. The cover is continually kept wet. As the water evaporates from the cover, heat is absorbed from the bottle and the water in the bottle becomes cold.

Boiling Point:

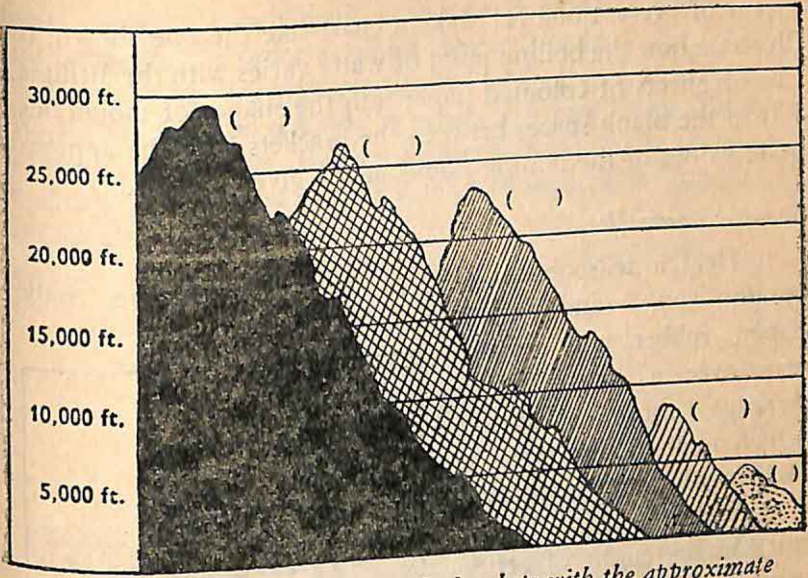
Since the boiling point of water drops with the increase in altitude (and the consequent decrease in pressure) food does not cook properly at the tops of high mountains.

Fill in the blanks:

Choose the correct words from this list and use them to fill in the blank spaces: raises, boiling, pressure, all, slow. body, expands, temperature, surface, certain, boil, rapid, lowers, melt, melting.

When a solid is heated it —— and its —— rises, until it begins to ——. Now the temperature remains constant until all the solid has changed to liquid. Thereafter the temperature rises until the liquid begins to ——. At this stage the temperature remains constant again, until all the liquid has changed to vapour.

The temperature at which a substance changes from the solid state to the liquid state is called the —— point of the substance. The presence of dissolved substances and the application of



Fill in the blank spaces between the brackets with the approximate values of the boiling points at the given heights
Left to Right : Mt. Everest, Mt. Nanga Parbat, Mt. Kailas, Mt. Dodabetta, Mt. Parasnath.

pressure —— the melting point of most substances.

Evaporation and —— are the two processes by which a liquid can change to vapour. Evaporation is a —— process and takes place at the —— of a liquid at —— temperatures. Boiling is a —— process and takes place throughout the —— of the liquid at a —— temperature called the boiling point of the liquid. The presence of dissolved substances and the application of pressure —— the boiling point of a liquid. As the —— on the surface of a liquid is lowered the boiling point decreases.

For your wall newspaper:

The boiling point of water falls approximately 1°C for an ascent of every 1,000 ft. Make a chart like the one shown, to illustrate how the boiling point of water varies with the altitude. Cut up sheets of coloured paper into the shapes of mountains. Fill in the blank spaces between the brackets with the approximate values of the boiling points at the given heights.

See for yourself:

1. Heat a teaspoonful each of alum, naphthalene, chalk, paraffin-wax, sand, silver paper, rubber and sealing-wax over a strong flame. Arrange those substances which melt in the order of their melting temperatures.

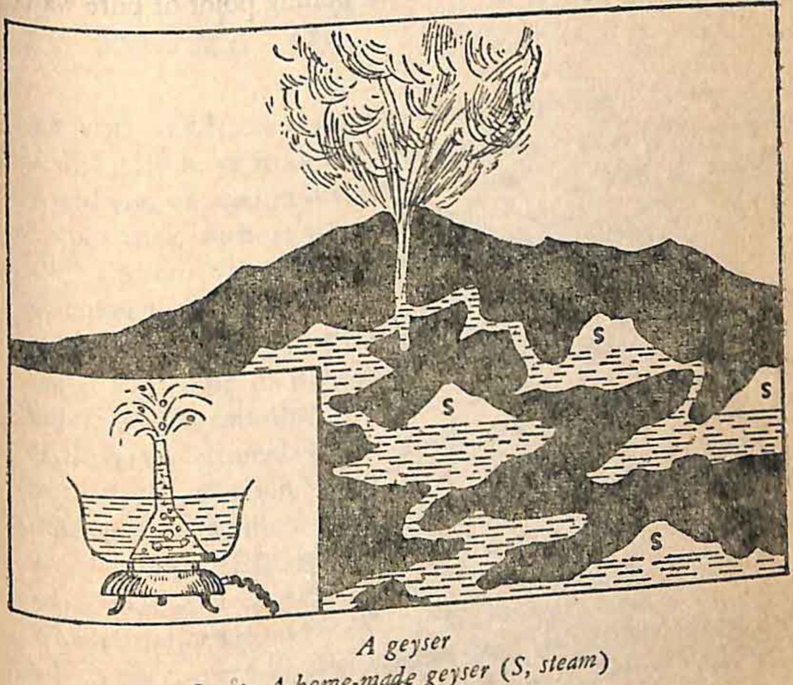
2. With the help of some salt and a length of string you can lift a piece of ice from out of a tumbler full of water. Wet one end of the string and lay it on top of the ice. Sprinkle some salt on each side of the string and on the part of the string which is on the ice. After a few moments gently pull the ice out with the string. Explain the result.

How to remove an ice cube from a tumbler full of water by means of a string

3. Pour a teaspoonful each of scent, glue, alcohol, ether, coconut oil, petrol, water, and turpentine into separate

saucers. Find out which liquid evaporates first. Make a list of these liquids in the order in which they evaporate.

4. Fill a pyrex dish with some water and place a funnel in it. Raise the funnel on one side by means of a small stone. Heat the water over a stove. Bubbles of steam form in the water, just above the stove and gathering in the mouth of the funnel, force out the water in the stem.



A geyser
Inset: A home-made geyser (S, steam)

The experiment you have just done illustrates how a geyser is formed. In places where geysers are to be found the great heat inside the earth changes some of the water underground into steam and forces it out in the form of spray.

In your note-book:

Describe how you would find (*a*) the melting point of butter; (*b*) that the presence of dissolved substances in water lowers its freezing point by an amount which increases with the amount of dissolved substances in the water; (*c*) that no matter how strong a solution may be, the temperature of the steam formed from the solution is the same as the boiling point of pure water.

PART II — CHEMISTRY

8

What Everything is made of

IF YOU could smash a lump of iron into tiny bits you would still only have iron. No other substance would appear nor would you succeed in breaking iron into anything else but iron. A substance, such as iron, which no one has yet been able to break up into two or more different kinds of substances is called an element.

Elements. After performing innumerable experiments, scientists have come to the conclusion that there are at least 92 different elements that are known to exist on and around the earth. These elements combine with one another in various ways to form the common things we see around us. Just as there are thousands of words made from only a few letters, so also there are thousands of things made from only a few elements. Moreover, just as there are some letters, such as q, u, x, y and z which are not used very often, so also are there a few elements which are rarely found in combination with other elements and which are very difficult to find, lurking as they do, in the far corners of the earth.

Some elements in their natural state are gaseous i.e. Oxygen, Nitrogen, Hydrogen, Chlorine and so on. Some like Mercury and Bromine are liquids. A great many are solids. Aluminium, Copper, Iron, Lead, Tin and Zinc are a few of the metallic elements we meet with in our daily life. Carbon, Iodine, Phosphorus, Silicon and Sulphur are examples of common non-metals.

Now let us consider two common elements, iron and sulphur, and find out something about their properties. Place some iron filings and powdered roll sulphur side by side. You will at once note that iron is lustrous and has a greyish colour, whereas sulphur is not lustrous and has a yellow colour. Iron is attracted by a magnet but sulphur is not attracted. Furthermore, if a piece of iron is put into a test tube containing dilute hydrochloric or sulphuric acid a gas will be given off. This does not happen in the case of sulphur. These simple experiments show that each of the two elements have their own separate and distinctive properties by which they can be identified.

Mixtures and Compounds. Take small quantities of iron and sulphur and mix them together. Although the colour of the mixture is somewhat different to the colour of the original substances in it, yet when viewed through a powerful magnifying glass the particles of iron can be easily distinguished from the particles of sulphur. If you run a magnet through the mixture, the iron particles in the mixture are attracted. In fact, a magnet can be used to separate the iron from the sulphur. Finally when the mixture is treated with dilute hydrochloric or sulphuric acid a gas is given off from the iron as before. We may conclude then, that even though the mixture appears to look like a separate substance, the elements of which it is composed retain their individual properties. Whether the mixture was made up of a small quantity of sulphur and a large amount of iron or vice versa it makes no difference, for when tested as above you will obtain the same results.

Now we all know that letters of the alphabet cannot be joined together in just any way to make a word, but instead must be combined in a certain definite way. Elements must also be combined in certain definite ways to make substances called compounds.

Take small quantities of iron and sulphur and mix them together in a test tube. Warm the tube over a flame. Soon a glow appears. You may now remove the tube from the flame. The glow gradually spreads through the contents of the tube. The heat produced is so great that the glass of the test tube melts or cracks. Obviously this heat has not come from the flame but from the chemical action taking place inside the test tube.

Break the test tube and inspect its contents. You will not be able to tell the iron from the sulphur even with the help of a magnifying glass, nor will you be able to separate the iron from the sulphur with the aid of a magnet. When acid is added to the substance, a gas is given off. Is it the same gas as before? Its smell will convince you that it is not.

The elements of which the new substance, called iron sulphide, is composed seem to have disappeared. Not a trace of them can be seen nor does the substance have the properties of its constituents. It has an appearance and properties of its own. The two elements have combined together to make a new substance which is called a compound.

An interesting fact about the compound we have just made, which is not possible to know from our experiments, is that the elements are combined together in definite proportions by weight.

A metal called Sodium combines with a poisonous gas called Chlorine to make a compound which we eat every day called common salt. Two gases, Hydrogen and Oxygen, combine together to form a compound without which life is not possible, a compound which is a liquid called water.

Physical and Chemical changes. If a bar of iron is heated over a strong flame it expands and becomes red hot. But in spite of these changes the iron bar does not become some other substance. On allowing the iron bar to cool, it regains its original length and colour. The change which the iron bar underwent when heated is an example of a physical change.

When we combined iron with sulphur to form iron sulphide, the two elements were converted into an entirely new substance, during the formation of which, heat was given off. Also, it was not possible to convert the iron sulphide back to the original substances. Such a change, as undergone by the iron and sulphur, is a chemical change.

Things to make and do

From your neighbourhood:

Make a collection of elements and compounds. Keep each substance separately in match-box compartments.

For your wall newspaper:

Illustrate this chapter with suitable sketches.

Fill in the blanks:

Choose the correct words from this list and use them to fill in the blank spaces: mixture, usually, physical, properties, water, do not, convert, definite, air, heat, compound, chemical, constituents, own, element, reversed, varying.

An —— is a substance which no one has yet succeeded in breaking up into two or more different kinds of substances. Every element has its own distinctive ——. The constituents in a mixture are mixed in —— proportions, but in a compound the constituents are combined in —— proportions. The constituents of a —— can be separated by mechanical means but this cannot be done in the case of a ——. A mixture has the properties and nature of its ——. A compound, however, has its —— distinctive properties and nature. Heat changes —— occur when a mixture is made. During the formation of a compound, however, heat changes —— occur. —— is an example of a mixture. —— is an example of a compound.

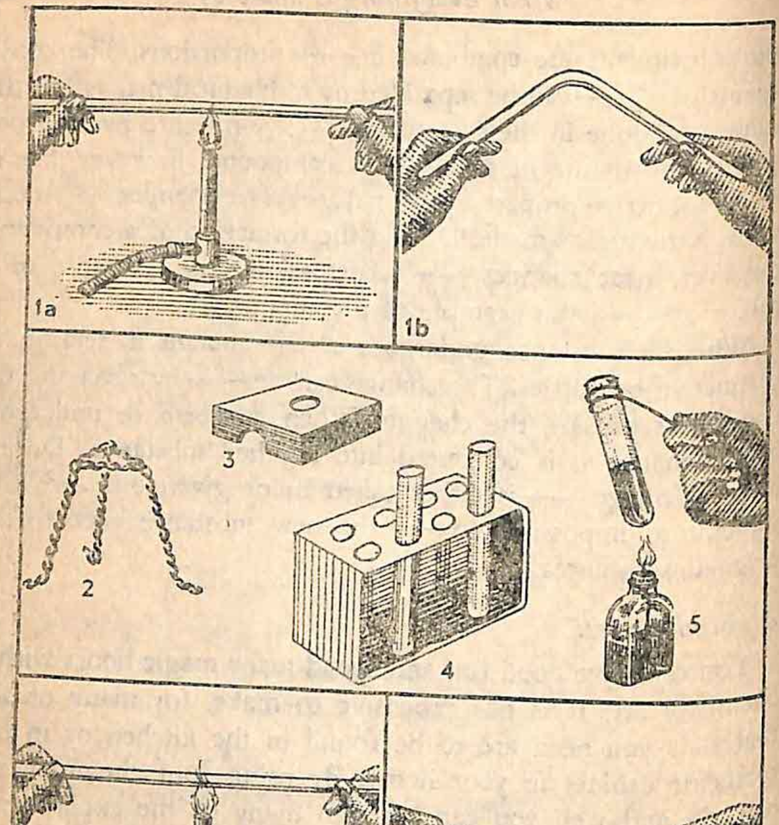
When a substance undergoes a —— change it retains its distinctive properties. The change can be —— by reversing the conditions causing the change. When a substance undergoes a —— change it is converted into another substance. During such a change —— is either taken in or given out and it is difficult or impossible to —— the new substance back to the original substances.

A chemistry set:

You can have good fun and spend many magic hours with a chemistry set. It is not expensive to make, for many of the materials you need are to be found in the kitchen or in the medicine cabinet in your home. By using your chemistry set cleverly and well you can perform many of the experiments described in this book, and thereby discover for yourself something of the marvels and wonders of science.

Some of the apparatus suggested below can be bought for a few naye paise, the rest are easily made.

1. Test tubes. 2. Test tube holder. This is made by bending and twisting a piece of wire into the shape shown in the picture. 3. Test tube rack. Cut away the bottom of a boot box and make holes on one side. 4. Glass jars. 5. Glass bottles. 6. Glass tubes. 7. Rubber tubes. 8. Funnels. 9. Candles. 10. A spirit lamp. This



Home-made apparatus

1. *(a. and b.) How to bend a glass tube.* 2. *Tripod stand.* 3. *Beehive-shelf.* 4. *Test tube rack.* 5. *Spirit lamp and test tube holder.* 6. *(a. and b.) How to make a glass jet.*

can be made from a bottle and a wick. 11. A tripod stand. Bend and twist a piece of thick wire to make a tripod stand as shown in the picture. 12. A beehive-shelf. This can be made from the cover of a tin. 13. A glass jet. Draw a piece of glass tubing to a point as shown and then break off the tip. 14. Bent tubes. Hold a glass tube so that its centre point is over a flame. When the glass softens, bend the tube to the required angle.

In your note-book:

1. Make lists of elements, compounds and mixtures that are in everyday use in your home.

2. Tabulate your observations of the experiments suggested in the chapter as follows:

Test	Iron	Sulphur	Mixture of Iron and Sulphur	Iron Sulphide
Appearance				
Action of magnet				
Action of dilute acid				

3. Identify as physical or chemical the changes that occur in each of the following:

(*a*) The rusting of an iron bar.

(*b*) The planing of a wooden board.

(*c*) The stretching of a piece of elastic.
(*d*) The burning of a candle.
(*e*) The beating of an egg.
(*f*) The adding of water to quicklime.
(*g*) The crushing of a rock.
(*h*) The striking of a match.
(*i*) The exploding of a cracker.
(*j*) The melting of wax.
(*k*) The freezing of a pond.
(*l*) The development of a photograph.
(*m*) The breaking of a tumbler.
(*n*) The gluing of two sticks together.
(*o*) The sharpening of a pencil.

9

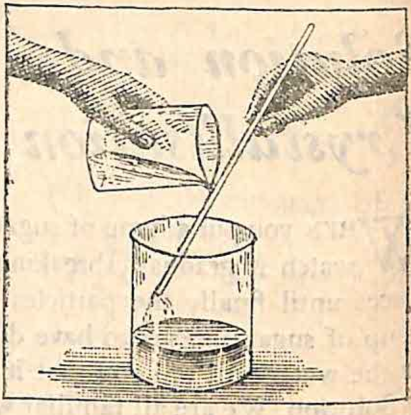
Solution and Crystallisation

WHEN you put a lump of sugar into a bowl of water, you can watch it gradually breaking up into smaller and smaller pieces until finally the particles are too tiny to be seen. The lump of sugar appears to have disappeared, but the sweet taste of the water will tell you that it is still present.

Solution. We are all familiar with the fact that certain substances like sugar and salt dissolve in water. If a solid substance dissolves in a liquid it is said to be soluble, but if it does not dissolve in the liquid it is said to be insoluble. The substance which dissolves is called the solute; the liquid in which it dissolves is called the solvent; and the resulting mixture of the solute and the solvent is called the solution.

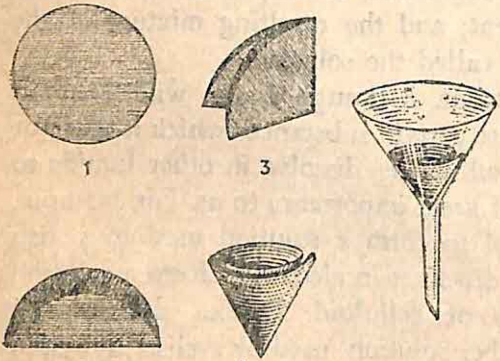
Solvents other than water. Although water will dissolve many substances, there are certain substances which it will not dissolve. Some of these substances dissolve in other liquids to form solutions that are of great importance to us. For example, resin dissolves in alcohol to form a solution used to polish furniture. Camphor also dissolves in alcohol to form a solution used in the manufacture of celluloid. Rubber dissolves in naphtha to form the 'rubber solution' used by cyclists. A liquid called Benzine is used by 'dry-cleaners' to remove grease spots from clothing.

Suspension. When an insoluble substance like chalk is powdered and shaken up with water, the fine light particles remain visible in the water and are said to be in suspension. Unlike a solution which is clear and transparent, a suspension is cloudy and not transparent. If the suspended particles are allowed to stand for some time they will settle down to the bottom of the vessel forming a sediment.



Decantation

How to separate an insoluble solid from a liquid. An insoluble solid can be separated from a liquid by either of the following two ways.

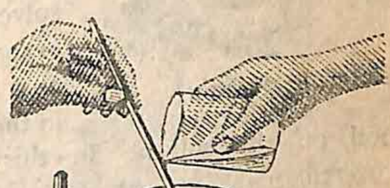


How to fold a filter paper

First mix a small amount of powdered chalk with some water in a beaker, and, after stirring well, allow the mixture to stand for some time. After a while the heavy particles settle down to the bottom of the beaker. Pour out the clear portion of the mixture as shown in the picture, taking care not to disturb the sediment. This method of separating the clear portion of a liquid from a sediment is known as decantation and is the process employed when a rapid and rough separation is necessary.

In the laboratory we separate an insoluble solid from a liquid by a process called filtration.

Prepare a filtering apparatus as follows. Fold a filter-paper into halves and then into quarters. Open it out into the form of a cone. Wet the paper cone and press it gently into a funnel. Support the funnel in the ring of a retort stand, and place a beaker underneath. Now add a small amount of powdered chalk to some water in a beaker and stir the mixture. Gently pour the contents of the beaker down a glass rod into the funnel taking care that the liquid does not rise above the top edge of the filter-paper. The clear liquid which passes through the filter-paper is called the filtrate while the solid material that collects in the funnel is called the residue.



Filtration

How to obtain a solute from a solution. It is a matter of common experience that water left exposed in a dish gradually changes to vapour, or, as we say, it evaporates. The higher the temperature. the more quickly does the water evaporate. If

Evaporation

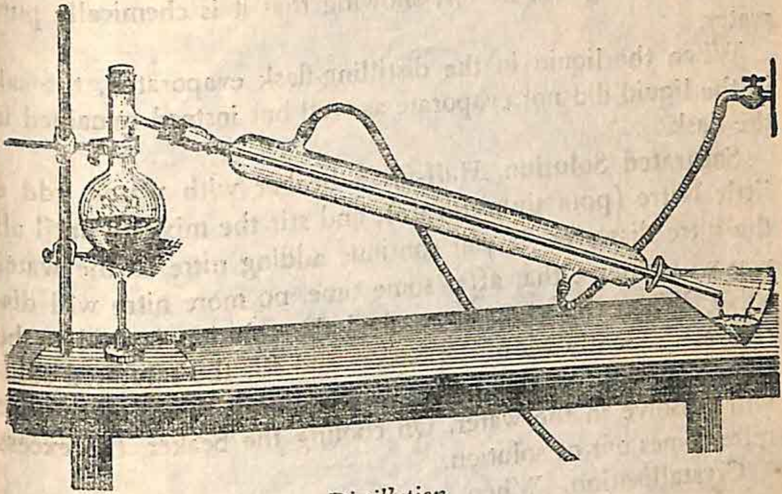
the dish containing water is heated over a strong flame, the water boils and changes to vapour more rapidly. Knowledge of this fact is made use of in separating a soluble substance from a solution.

Add a small amount of salt to some water in a beaker. Stir the mixture well, until all the salt dissolves. Pour the solution into an evaporating dish and place the dish on a tripod stand. Heat the solution in the dish over a bunsen flame and boil off the solvent. In this way the salt will be recovered.

How to separate a soluble substance from an insoluble substance when both substances are mixed together. Since the particles of a dissolved substance are small enough to pass through the pores of a filter paper, filtration will help us to separate soluble from insoluble. **substances when such substances are mixed together.**

Add a little of the given mixture of salt and sand to some water in a beaker. Stir the contents of the beaker and then filter. Catch the filtrate in an evaporating dish. The sand in the mixture collects on the filter paper while the salt solution passes through and drips into the dish. The salt can be recovered by evaporating the solution to dryness.

How to obtain a solvent from a solution. The change of a substance from the liquid to the vapour state is called evaporation while the change from vapour to liquid is called condensation. The double process of evaporation and condensation is known as distillation. By means of this process a solvent can be obtained from a solution.



Distillation

Half-fill a distilling-flask with salt solution and fit it with a cork. Fit the side-tube of the flask to the inner tube of a condenser. Connect the bottom tube of the condenser to a tap, by means of rubber tubing. Join one end of another length of rubber tubing to the top tube of the condenser and place the other end in the sink. Put a conical-flask at the lower end of the condenser.

Heat the distilling-flask and open the tap. Water from the tap fills the outer jacket of the condenser and flows off from the top side-tube into the sink. When the liquid in the flask boils, the vapour given off passes into the inner tube of the condenser, and due to the cooling action produced by the circulation of cold water in the outer jacket, condenses, and trickles into the conical-flask. A liquid collected in this way is called the distillate. In this case the distillate is distilled water. If a portion of it is evaporated in an evaporating dish you will observe that no residue will be left showing that it is chemically pure water.

When the liquid in the distilling-flask evaporated, the salt in the liquid did not evaporate as well but instead remained in the flask.

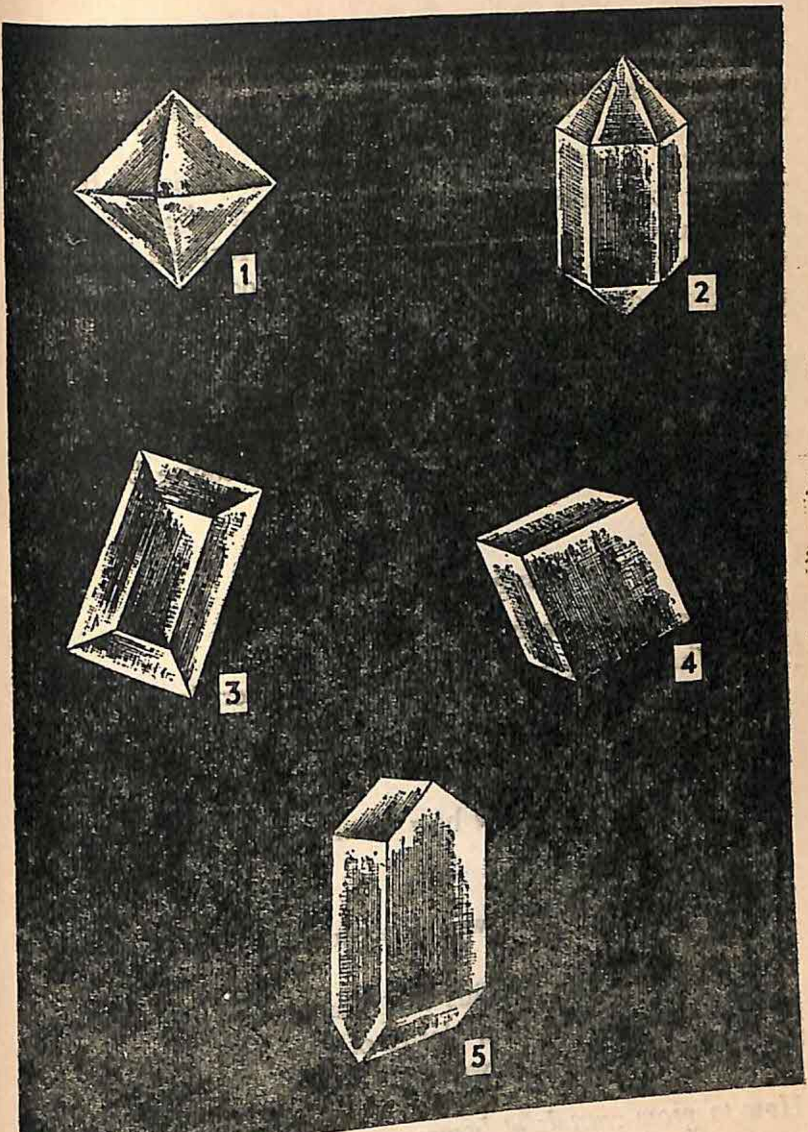
Saturated Solution. Half-fill a beaker with water, add a little Nitre (potassium nitrate), and stir the mixture until all the nitre dissolves. If you continue adding nitre to the water you will observe that after some time, no more nitre will dissolve. When this stage is reached the solution is said to be saturated. Gently warm the beaker and stir the saturated solution. You will find that as the temperature is raised more nitre will dissolve in the water. On cooling the beaker, the excess nitre comes out of solution.

Crystallisation. When a solid comes out of solution, it separates out in the form of particles having definite geometrical shapes, each bounded by flat, regular surfaces. These particles are called crystals and the process by which they are obtained is called crystallisation.

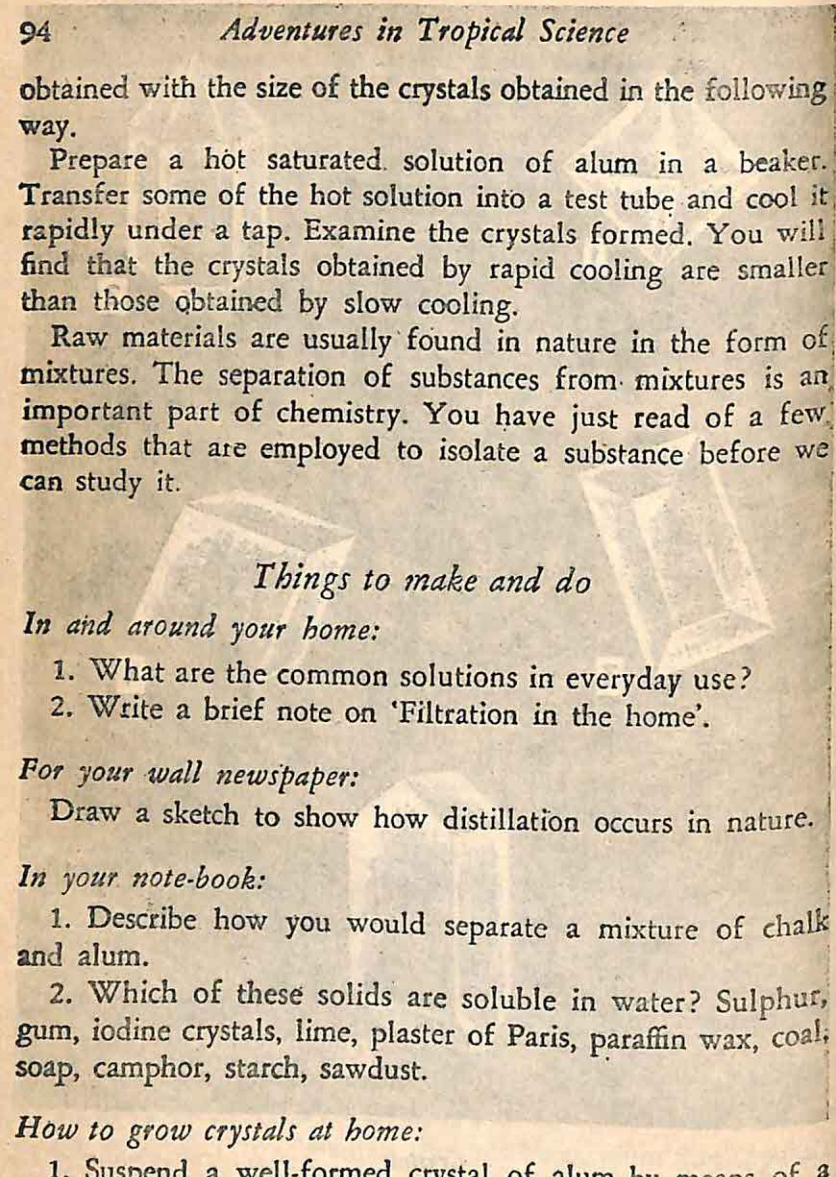
Crystals of a particular solid show the same shape. A crystal of Common salt is shaped like a cube, whereas a crystal of Alum is shaped like a double pyramid. Solids which are not crystalline are called amorphous solids.

Although the crystals of a particular solid have the same shape they differ in size depending on the method by which they have been obtained.

Allow a hot saturated solution of alum to stand in an evaporating dish and examine the crystals of alum that separate from the solution. Compare the size of the crystals so



Crystals
1. *Alum.* 2. *Quartz.* 3. *Washing Soda.* 4. *Common salt.*
5. *Epsom salts.*



obtained with the size of the crystals obtained in the following way.

Prepare a hot saturated solution of alum in a beaker. Transfer some of the hot solution into a test tube and cool it rapidly under a tap. Examine the crystals formed. You will find that the crystals obtained by rapid cooling are smaller than those obtained by slow cooling.

Raw materials are usually found in nature in the form of mixtures. The separation of substances from mixtures is an important part of chemistry. You have just read of a few methods that are employed to isolate a substance before we can study it.

Things to make and do

In and around your home:

1. What are the common solutions in everyday use?
2. Write a brief note on 'Filtration in the home'.

For your wall newspaper:

Draw a sketch to show how distillation occurs in nature.

In your note-book:

1. Describe how you would separate a mixture of chalk and alum.

2. Which of these solids are soluble in water? Sulphur, gum, iodine crystals, lime, plaster of Paris, paraffin wax, coal, soap, camphor, starch, sawdust.

How to grow crystals at home:

1. Suspend a well-formed crystal of alum by means of a

thread in a cold saturated solution of alum. Examine the crystal daily and watch it grow.

2. Prepare a hot saturated solution of Epsom salts (Magnesium sulphate). Allow the solution to cool and add a few drops of glue. Now stir the mixture well. Spread some of the mixture onto a slide of glass and wait for the result. Within a few minutes needle-shaped crystals will make their appearance.

3. Prepare a hot saturated solution of potassium chlorate in a test tube. Cool the test tube rapidly under a tap. The crystals which come out of solution gently fall through the liquid producing a very pretty effect.

Fill in the blanks:

Choose the correct words from this list and use them to fill in the blank spaces:

evaporation, hot, geometrical, sand, decantation, crystals, saturated, soluble, solvent, filtration, slow, insoluble, solution, salt, distillation, cold, regular, rapid, solute.

A substance that dissolves in a liquid is said to be ——, but if it does not dissolve it is called ——. —— is soluble in water, whereas —— is insoluble. The substance which dissolves is called the ——; the liquid in which it dissolves is called the ——; and the resulting mixture is called the ——. When a liquid has dissolved as much as it can of a substance at room temperature, it is said to be ——. As a general rule, a —— liquid will dissolve more of a solid than a —— liquid.

Suspended impurities can be separated from a liquid by ——. The usual laboratory method, however, employed for such a purpose is ——. A solute can be separated from a solution by ——. A soluble substance can be separated from an insoluble substance by the double process of filtration and evaporation. A solvent can be obtained from a solution by ——.

A solid comes out of solution in the form of ——. A crystal has a definite —— shape and is bounded by flat —— faces. Crystals of a particular solid have the same shape and when obtained by —— cooling are smaller in size than when obtained by —— cooling.

10

Combustion and Flame

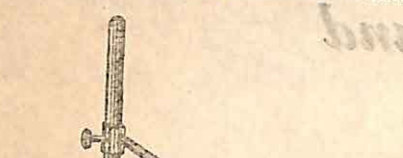
THE burning of paper, wood and coal are familiar everyday occurrences in our homes. When the fire in the kitchen does not burn well, a poker is used to rake out the ash below the fire and to make a place among the coals for a draught of air to enter. Sometimes the fire is made to burn more brightly by increasing the supply of air with the help of a hand-fan. Without air, burning will not take place.

You will remember having read in Book IV that only a certain part of the air, a gas called oxygen, helps things to burn.

Combustion. When a substance burns in air it does not merely combine with oxygen, but gives out heat and light as well. The change which takes place is a chemical change and is called combustion. When a match burns, heat and light are given out and the wood is completely changed. This is an example of combustion. The filament in an electric lamp becomes white hot when a current is passed through it, but though it gives out heat and light it does not change to some other substance, so we should not say that it burns.

Substances that burn are called combustible substances. A gas, like Oxygen, which does not burn itself but allows things to burn in it is called a supporter of combustion.

Ignition Temperature. The temperature to which a substance must be heated to start combustion is the ignition temperature of that substance.



To show that different combustible substances have different ignition temperatures

Different combustible substances have different ignition temperatures. We can compare the ignition temperature of a few substances by a simple experiment.

Place a rectangular piece of metal on the ring of a retort stand. Adjust a bunsen burner below so that it is exactly in the centre of the ring. Now arrange the following substances in a circle on the metal: a matchhead, coal, paper, sugar, wood, sulphur and a mixture of equal parts of potassium chlorate and sugar. Light the burner and observe the order in which each of these substances begins to burn.

When we wish to start a fire in the kitchen-grate we first put in a few pieces of paper, then some chips of dry wood and lastly a few lumps of coal. We next strike a match. The temperature of the flame is high enough to raise the temperature of the paper to its ignition temperature and so cause combustion. The heat given out by the combustion of the paper raises the temperature of the wood to its ignition temperature with the result that it is soon alight. The heat produced by the combustion of the wood in turn, raises the temperature of the coal to its ignition temperature and soon we have a blazing fire in the grate.

Substances like petrol and methylated spirit are called inflammable substances because they catch fire easily. This is because both these substances have low ignition temperatures.

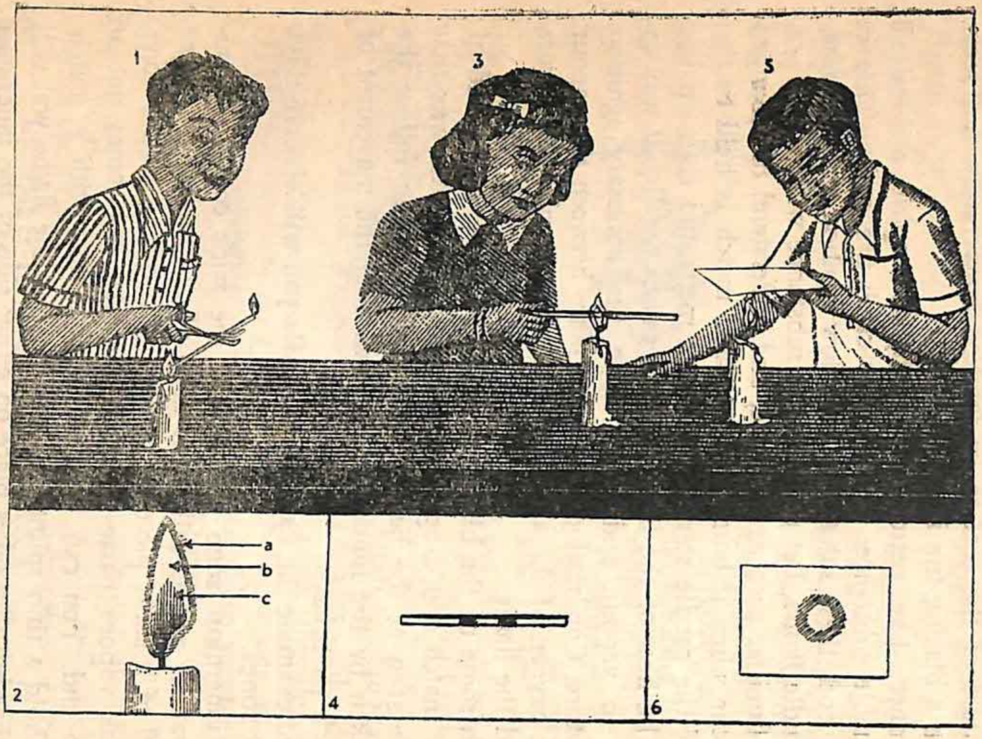
A candle flame. Let us choose a substance with which we are all familiar such as a candle, and understand the changes that occur when it burns. As a lighted match is held to the wick of the candle some of the wax melts and rises up the wick. The heat of the lighted match causes the liquid wax to change to vapour, and raises it to the necessary ignition temperature. Combustion then takes place between the vapour and the oxygen of the air. The place where combustion occurs is called the flame.

Crush some of the black material that forms at the end of a burnt match and drop the powder into the liquid wax that is to be seen at the base of the wick. You can follow the path taken by the liquid wax by watching the movement of the black particles.

If you examine the flame of a candle you will observe three distinct zones.

The innermost zone just around the wick consists of unburnt vapour and is called the zone of no combustion. Place one end of a short piece of narrow glass tubing in this zone. The wax vapour passes through the tube and comes out at the top end. You can light the vapour here with a match. If you hold a thin splinter of wood across the flame you will notice that burning takes place on either side of the innermost zone but not in the zone itself.

The middle zone of the candle flame is the largest part of



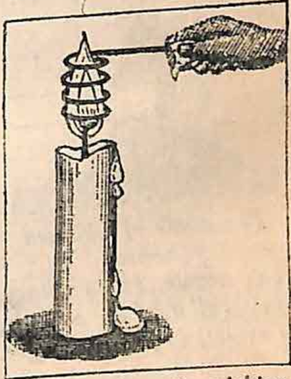
Experiments with a candle flame

1. *Burning vapour at the end of a tube.* 2. *Parts of a candle flame:* (*a*) *Zone of complete combustion,* (*b*) *Zone of incomplete combustion,* (*c*) *Zone of no combustion.* 3. *The splint burns at the outside of the flame.* 4. *The splint after the experiment.* 5. *Holding a piece of cardboard over the flame.* 6. *The scorch-mark.*

the flame and is the region where there is the most light. Here the vapour does not get enough air to burn completely and so this part is called the zone of incomplete combustion. Candle wax contains two elements, hydrogen and carbon, both of which are combustible. In this zone tiny particles of carbon become so hot that they glow and give out light. Hold a cold evaporating dish over the flame. Some of the carbon particles cool down to the extent that they do not burn and are deposited on the bottom of the dish as soot.

Combustion is obviously best in the outside edge of the flame. Here the vapour gets enough air to burn completely. In this region of the flame, called the zone of complete combustion, carbon particles are consumed, with the result that the zone is colourless. Hold a piece of cardboard in a horizontal position in the flame for an instant. The pattern of the scorch-mark on the cardboard will show you that the region of the highest temperature is the zone of complete combustion.

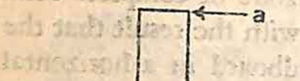
You have probably noticed that a candle burning in a draughty place burns with a smoky flame. The reason for this is that the cold air cools the flame and slows down combustion. As a result most of the carbon particles which reach the edge of the flame do not burn but form smoke instead.



A way of extinguishing the flame of a candle

The usual way of extinguishing the flame of a candle is by blowing on it. Once the vapour is cooled below its ignition temperature the candle goes out. There is, however, another way of extinguishing a candle flame. Place a coil of copper wire around the flame of the candle. The heat of the flame is rapidly conducted away by the copper wire with the result that the flame goes out.

No matter what fuel is burnt the process of combustion is the same. Paper, wood, coal, kerosene oil, and methylated spirit are a few of the fuels in common use. Each one of these substances contains carbon and hydrogen. During combustion, the oxygen of the air combines with the carbon to form carbon dioxide and with the hydrogen to form water. You cannot see these products since carbon dioxide is an invisible gas and the water changes to vapour as soon as it is formed.



The inside of a bunsen burner
(*a*) *nozzle*, (*b*) *chimney*, (*c*) *collar*, (*d*) *air-hole*, (*e*) *jet*, (*f*) *inlet for gas.*

A bunsen burner. In our study of a candle flame we saw that complete combustion occured in the outside edge of the flame where the best supply of air was available. Now if we want a very hot flame, we must mix plenty of air with the gas we intend to burn. This is done in the case of a bunsen burner.

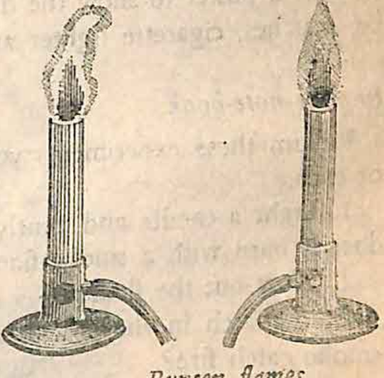
Examine a bunsen burner and find out how it works. You will see that it is made up of three parts. These parts are the chimney, the collar and the jet. The chimney is screwed on to the jet, and the collar is fitted loosely around the lower end of the chimney so that it can be turned round. There is a hole in the collar and another hole at the lower end of the chimney. By twisting the collar around the chimney you can open or close the hole and thus regulate the supply of air that enters the chimney.

Now turn on the gas and light the burner. Adjust the collar so that the air-hole is open. As the gas rushes through the burner a partial vacuum is set up in the neighbourhood and air is sucked in through the hole. The air mixes with the gas in the chimney so that the flame burning at the nozzle has air both inside and outside it as well. The result of this is that all the carbon in the gas burns at once to carbon dioxide and we see a clean bluish-green flame which is very hot. This flame has two zones: an inner zone of unburnt gas, and an outer zone of complete combustion.

When the air-hole of the burner is closed the flame is bright and smoky. Due to the insufficient supply of air the gas does not burn properly and now contains unburnt particles of carbon which glow and give out light. Some of the carbon particles escape unburnt and form smoke. The flame is large since the gas must find plenty of air outside the burner with which to combine, and, like a candle flame consists of the same three zones.

You can make the flame of a bunsen burner travel down the chimney by performing a simple experiment.

Open the air-hole of the burner, turn the gas on and light it. Now gradually turn off the tap. You will notice the flame becoming lower



Bunsen flames
Left: Air-hole closed
Right: Air-hole open

and lower until suddenly there is a pop followed by a shriek in the pipe. The flame has gone down the chimney and is now to be found at the jet. We say that the flame has 'struck back'. You can get the flame back to its proper place by giving the rubber tube a sharp thump. When you do this the sudden increase in pressure pushes the flame up the tube. Open the tap completely and be sure the flame stays at the nozzle.

Things to make and do

In and around your home:

Examine the oil lamps and stoves used in your home and in your neighbourhood. Find out how they have been designed and the way in which they work. Try to make a sectional drawing of the lamps and stoves you examine.

For your wall newspaper:

Make a poster to show the different ways of starting a fire, i.e. matches, cigarette lighter and so on.

In your note-book:

Peform these experiments yourself and explain the results of each.

1. Light a candle and gently lower it into a jam-jar. Why does it burn with a smoky flame?

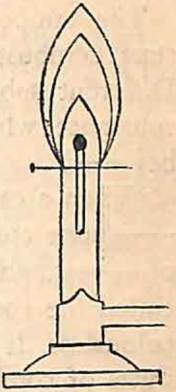
2. Blow out the flame of a candle and immediately hold a lighted match in the smoke near the wick. Why does the smoke catch fire?

3. Light a bunsen burner and close the air-hole. Hold a test tube containing cold water over the flame. Is there any carbon

deposited on the underside of the test tube? What is the result if you repeat the experiment with the air-hole open?

4. Poke a pin through a match stick, just below the head of the match. Now put the match down the nozzle of a bunsen burner so that it hangs down the chimney supported by the pin. Does the matchhead burn when the burner is lit?

5. Take a bent glass tube which has one end fashioned into a jet. Blow into a candle flame. Describe the kind of flame produced.



Though the matchhead, is in the middle of the flame it does not burn

Fill in the blanks:

Choose the correct words from this list and use them to fill in the blank spaces: air, partial, inflammable, three, ignition, water vapour, heat, smoke, open, no, combustible, middle, light, inner, outermost, closed, carbon dioxide, complete.

Combustion is a chemical change which is accompanied by the production of —— and ——. Substances which burn are called —— substances.

Describe the kind of flame produced by blowing into the flame of a candle

The temperature to which a substance must be heated to start combustion is the —— temperature of that substance. Different substances have different ignition temperatures. A substance which has a low ignition temperature is said to be ——.

When a candle burns its flame has —— distinct zones. The —— zone consists of unburnt vapour and is called the zone of —— combustion. The —— zone has the most light and is called the zone of —— combustion. The —— zone is hot and colourless. It is called the zone of —— combustion. The products of combustion in the case of a candle is —— and ——.

A bunsen burner has a hole at the lower end to allow —— to enter. When the hole is —— the resulting flame is hotter and gives off less —— than when the hole is ——.

Secret invisible writing:

When lemon-juice is put on a sheet of paper, a chemical change takes place and the part of the paper which comes in contact with the juice is changed into a compound. The kindling temperature of this compound is lower than the rest of the paper. You can make use of this knowledge to send a secret message to a friend.

Secret writing

Dip a pen with a clean nib into some

lemon-juice and write the message on a sheet of writing paper. When the lemon-juice dries on the paper, not a trace of it is left.

To make the invisible writing visible you must gently heat the writing paper over a candle. While heating, move the paper back and forth so that the heat from the candle is uniformly distributed to each part of the paper. Since the secret writing has a lower ignition temperature than the rest of the paper, it combines with the oxygen of the air at a lower temperature than the paper does. As a result it chars first, gets darker and becomes visible.

The compound formed by the action of vinegar on paper also has a lower kindling temperature than paper and may be used instead of lemon-juice to make secret writing.

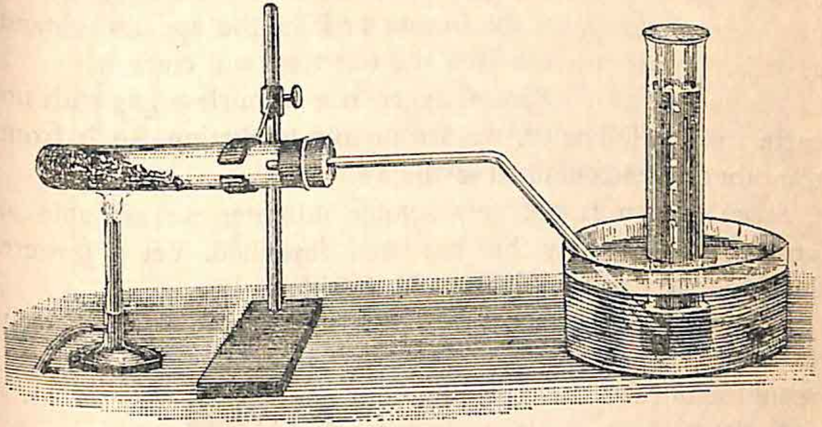
II

Two Useful Gases — Oxygen & Carbon Dioxide

You have already learnt that air is a mixture of gases and that one-fifth of its volume is oxygen. Without this gas all living things would suffocate and die. It is also necessary for burning, rusting and decay. Since oxygen is so essential to us and because of the important part it plays in Chemistry we ought to know more about it.

Preparation of Oxygen. In the laboratory,oxygen is prepared by heating substances which are rich in oxygen. A crystalline substance called potassium chlorate contains a large quantity of oxygen, but it only gives up its oxygen when heated to a high temperature. If, however, we mix it with a black powder called manganese dioxide we can get oxygen from it more easily and at a lower temperature. After heating, the potassium chlorate having given up its oxygen, is changed to potassium chloride, but the manganese dioxide remains unchanged. A substance such as manganese dioxide, which by its mere presence hastens the rate of reaction, is called a catalytic agent.

Mix some potassium chlorate with one-quarter of its weight of manganese dioxide and put the mixture in a hard glass test tube. Support the test tube in a horizontal position between the clamps of a retort stand. Fit a one-holed stopper to the test tube. Pass one end of a delivery tube through the stopper and let the other end dip into a large trough three-fourths full of water. Place a beehive-shelf over this end to support the gas jar in which the gas is to be collected.



Arrangement for collecting oxygen by the displacement of water

Gently heat the test tube. You will at once notice bubbles of gas rising through the water in the trough. These first few bubbles of gas contain mostly air which was in the test tube and delivery tube. Allow these bubbles to escape. When a steady flow of bubbles comes from the delivery tube, make arrangements for collecting the gas.

Fill several gas jars with water and cover each with a greased glass plate. Now take one of the gas jars, invert it and lower it carefully into the trough of water. Put it over the top hole of the beehive-shelf and remove the glass plate. The gas rises into the jar and soon displaces the water in it.

The moment the jar is full of gas, slide a glass plate over its mouth and lift it out of the water. Turn the jar right way up and place it, still covered, on a table.

Collect several jars of oxygen in this way. This method of collecting a gas is known as the displacement of water method.

At the end of the experiment raise the delivery tube out of the water in the trough before you turn the bunsen burner off. If you extinguish the burner and let the apparatus stand as it is, water will rush into the test tube and crack it.

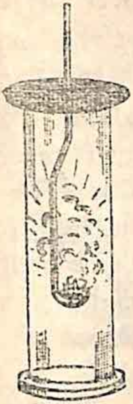
Properties of Oxygen. Oxygen is a colourless gas with no taste or smell. Hence, we are unable to distinguish it from the other gases contained in the air.

Since oxygen is not very soluble in water we are able to collect it in the way that has been described. Yet if it were insoluble in water no fish would be able to live.

Combustible substances burn far more rapidly and fiercely in oxygen than they would in air. A glowing splinter of wood thrust into a jar of oxygen bursts into flame. A burning candle lowered into a jar containing the gas burns with a larger and brighter flame. Glowing charcoal taken in a pair of tongs and held in the gas burns brilliantly giving off sparks. Burning sulphur taken in a metal spoon, called a

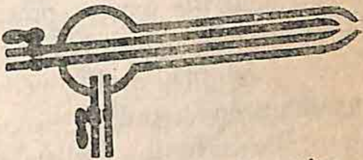
Iron burns in oxygen

deflagrating spoon, and plunged into the gas burns more brightly. Even iron burns in oxygen.



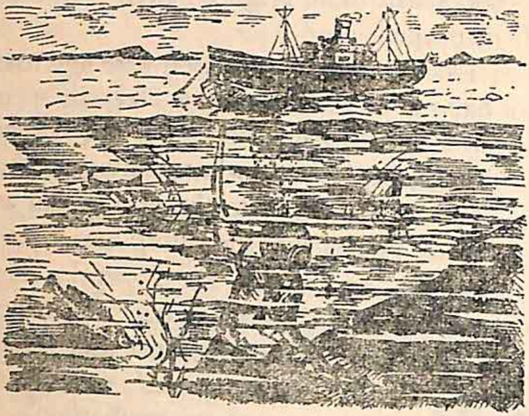
Sulphur burns brightly in oxygen

Take a piece of thin iron wire and make one end into a little spring. Heat the spring in a bunsen flame until it is red hot and then dip it into a bowl containing sulphur. The sulphur sticks to the iron spring and burns. Now lower the spring into a jar of oxygen, and watch the fireworks effect produced as the iron burns. The experiments described above show that though oxygen does not burn itself, nevertheless it is a good supporter of combustion.



The inside of a blow-pipe

Uses of Oxygen. The fact that substances burn rapidly and fiercely in oxygen with a high temperature is put to use in the cutting and welding of certain metals such as iron. The instrument used for such a purpose is called a blow-pipe. A gas called Acetylene is passed through one of the side pipes of the instrument. Unlike Oxygen this gas burns. Oxygen is supplied through the second pipe to make the acetylene burn with a very hot flame. The flame thus produced has a temperature of over 3,000°C and can burn even under water. Sheets of iron and steel cannot withstand the heat from this flame and are cut in two. If a ship carrying valuable cargo suffers shipwreck and sinks, divers are sent down into the sea. With their oxy-acetylene blow-pipes they cut a hole through the iron sides of the ship, enter within and recover the cargo.



Cutting through the sides of a ship

The oxy-acetylene flame is also used to join two pieces of iron. The terrific heat of the flame melts the ends, which when softened, stick together easily. This process is called welding.

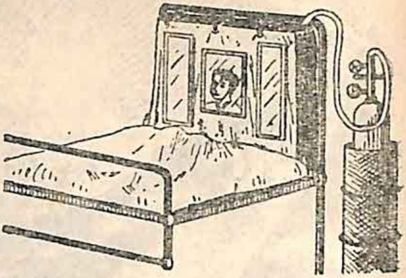
Welding

Although the oxygen present in the air is enough to satisfy the needs of a normal healthy person breathing under ordinary conditions, there are times when it is essential for a person to breathe in pure oxygen.

Mountaineers and airmen who go far above the earth take with them a supply of oxygen, for here the air is not enough and they find it difficult to breathe. In hospitals too, this gas is used by doctors. A person suffering from damaged lungs is not able to breathe very well. The oxygen he takes in is not enough for his needs. The patient is laid in bed and a special tent placed over his face. Oxygen from a container is passed into the tent.

Climbing to dizzy heights

Under these conditions he receives treatment. When he is well again, the tent is removed and he is able to breathe ordinary air again.



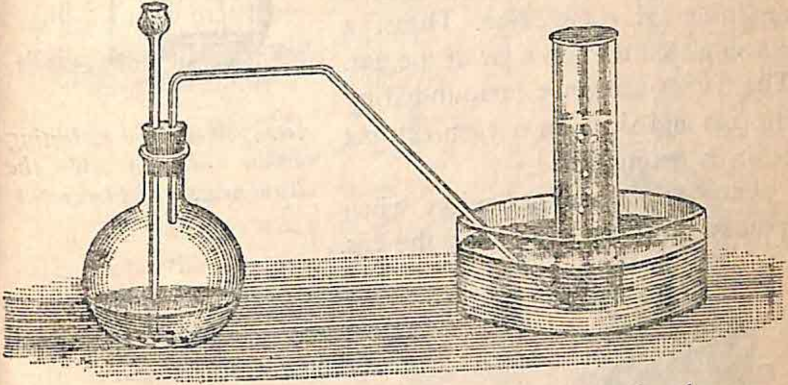
An oxygen tent

Carbon Dioxide. Although most of the air consists of nitrogen and oxygen there are small quantities of other gases present as well, the chief of which is carbon dioxide. In spite of the fact that this gas is continually being formed as a result of breathing, burning and decay you may think it strange that only three parts in ten thousand of the air are carbon dioxide. The solution to this mystery is that since the gas is absorbed by green plants in the daytime for the important purpose of manufacturing starch the amount of carbon dioxide in the air remains constant.

Preparation of Carbon Dioxide. Not all substances form carbon dioxide when they burn, but only those that contain the element carbon. Carbon dioxide may, therefore, be obtained by burning any fuel containing carbon. The gas may also be prepared by strongly heating any form of calcium carbonate such as limestone, marble and chalk (not the chalk used in the classroom). As it is inconvenient to prepare carbon dioxide by any of the two methods outlined above, carbon dioxide is prepared in the laboratory by the action of acid on calcium carbonate.

Fit a two-holed stopper to a flask and insert a thistle funnel through one hole and a delivery tube through the other. Place a few pieces of marble chips in the flask and arrange the delivery tube so that one end of it dips beneath a beehive-shelf placed in a trough of water.

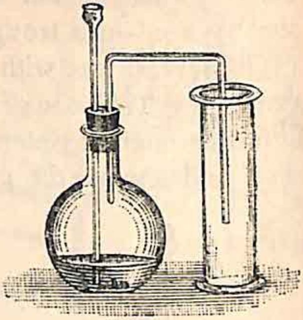
Fill several jars with water and cover each with a greased glass plate. Take one of the jars, invert it, and lower it carefully into the trough of water. Put it over the top hole of the beehive-shelf and remove the glass plate.



Arrangement for collecting carbon dioxide by the displacement of water

Pour dilute hydrochloric acid down the thistle funnel. As the acid touches the marble chips, there is a chemical reaction and carbon dioxide is given off. Make sure that the lower end of the thistle funnel dips below the surface of the acid in the flask or the gas will escape out of the funnel instead of entering the delivery tube. Though the gas is fairly soluble in water, it can be collected by the displacement of water since large volumes of it are produced.

Another method of collecting the gas is by the upwnward displacement of air. In this method the beehive-shelf and trough of water are replaced simply by a gas jar. Since carbon dioxide is heavier than air it sinks down to the bottom of the jar displacing the lighter air.



Arrangement for collecting carbon dioxide by the upwnward displacement of air

Properties of Carbon Dioxide. Carbon dioxide is a colourless gas with a faint smell and a sharp taste.

It is not combustible nor is it a supporter of combustion. Thrust a burning splinter into a jar of the gas. The flame is at once surrounded by the gas and since no oxygen can get to it, is extinguished.

Lime water becomes milky when poured into a jar containing the gas. This property distinguishes carbon dioxide from all other gases.

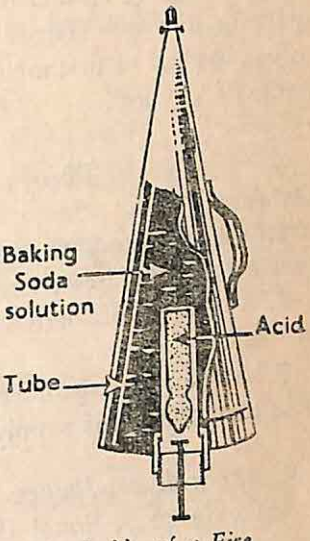
How carbon dioxide can be poured from one gas jar to another

The gas is about one and a half times heavier than air. Pour carbon dioxide from one gas jar to another by inverting a jar containing it over an 'empty' jar (i.e. a jar containing air). Now test for the presence of carbon dioxide in the lower jar either with lime water or by means of a burning splinter. Because it is a heavy gas it collects in low places such as old wells and mines. Anyone going into these places must previously test them by lowering a lighted candle. If the candle is extinguished it means that carbon dioxide is present and there is the danger of suffocation.

As already mentioned, carbon dioxide is soluble in water. It dissolves in water to form a weak acid called carbonic acid. Blue litmus paper turns red when put into the solution.

Uses of Carbon Dioxide. The fact that carbon dioxide puts out a fire is made use of in fire fighting with fire extinguishers.

A fire extinguisher is filled with a strong solution of baking soda (sodium bicarbonate). Above the plunger at the lower end is a bottle containing acid. To work the extinguisher the bottom of it is banged and the plunger pushed inwards. This action results in the breaking of the bottle. When the acid comes in contact with the solution of baking soda a large quantity of carbon dioxide is produced. The gas exerts a pressure on the liquid forcing it up the side tube and out at the nozzle. The liquid quenches the fire and the gas smothers it.



The inside of a Fire Extinguisher

Soda water is made by exerting considerable pressure on carbon dioxide and forcing it into water where it dissolves. When you remove the cap from a soda-water bottle the pressure is lessened and carbon dioxide comes fizzing out.

Carbon dioxide can be easily changed into a liquid and then frozen into a solid. Solid carbon dioxide is very cold and looks like ice. In this form it is sold as 'dry ice'. Blocks of 'dry ice' are cut into smaller blocks and used as a cooling agent for preserving ice-cream and certain perishable food-stuffs such as meat and fish. 'Dry ice' has three main advantages over ordinary ice. Firstly, it is colder than ice; secondly, it changes directly to gas on evaporation, without passing through the liquid state, and is therefore cleaner to use; thirdly, evaporation takes place at a very slow rate. The fact that solid carbon dioxide evaporates to gas instead of first melting to liquid has given it the peculiar name of 'dry ice'.

Things to make and do

Outdoors:

1. Visit a factory where oxygen is manufactured. During your tour of the premises try to understand everything you see.

2. Visit a shop where welding is done and watch the welders at work.

3. Ask an ice-cream vendor to show you the 'dry ice' he uses to preserve his supply of ice-cream.

For your wall newspaper:

Make large sectional drawings to show how oxygen and carbon dioxide can be prepared in the laboratory. Label each drawing.

In your note-book:

1. Say whether oxygen or carbon dioxide is given off when the following substances are strongly heated: (*a*) potassium permanganate; (*b*) sodium bicarbonate; (*c*) potassium nitrate.

2. Describe how you would show that (*a*) carbon dioxide is produced when a piece of charcoal burns in oxygen, (*b*) soda-water contains carbon dioxide.

An investigation you can make:

The story of how oxygen was discovered is an interesting one. Consult books in your science library and prepare a note for a class discussion on the subject.

Fill in the blanks:

Choose the correct words from this list and use them to fill in the blank spaces:

catalyst, 'dry ice', potassium chlorate, oxy-acetylene flame, mineral waters, slightly, combustion, milky, fairly, manganese dioxide, water, calcium carbonate, air, respiration, hydrochloric acid, reaction, carbonic acid.

Oxygen is prepared in the laboratory by heating a mixture of —— and ——. The latter substance acts as a —— i.e. by its mere presence it hastens the rate of ——. The gas is collected by the displacement of ——.

Oxygen is a colourless gas with no taste or smell. It is —— soluble in water. It does not burn but it is a good supporter of combustion.

Oxygen is used to produce the —— and as an aid to ——.

Carbon dioxide is prepared in the laboratory by the action of —— on ——. The gas is usually collected by the downward displacement of ——.

Carbon dioxide is a colourless gas with a sharp taste and a faint smell. It does not burn nor does it support ——. It turns lime water ——. It is heavier than air. It is —— soluble in water and dissolves in water to form ——.

Carbon dioxide is used to put out fires, in the making of ——, and, in the solid form, as ——.

PART III — BIOLOGY

12

What All Living Things Can Do

WHILE rambling in the countryside, have you ever been horrified to discover that an object which you thought was a stick suddenly proved to be a snake? It is at such a moment that we wonder about the differences between living and non-living things.

In the world there are a great many things which, when we sort them out, fall into either of two groups: living or non-living. The first two parts of this book dealt with non-living things. We will now read about living things.

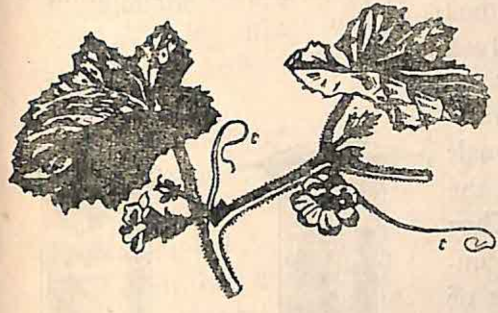
Living things move. We usually identify a thing as living if it moves. Animals move freely from place to place in search of food or to escape from their enemies. Plants also move, though not in the same way as animals. Their motions are usually very slow.

There are many non-living things which have this characteristic of movement. We all know that a motor-car can move, and that a cart will roll down a slope. How then can we distinguish the movements of living things from those of non-living things?

All living things have the power to move, whereas non-living things cannot move by themselves, but only when some outside force causes them to move.

Living things respond to external stimuli. If we touch a hot stove we immediately jerk our hands away. The heat from the stove is said to be a stimulus and the sudden movement of the hand from the hot stove is called a response.

All living things respond to external stimuli. Animals can hear, see, smell, taste or feel. Most animals have special parts which help them to respond to external stimuli in their surroundings. Although plants are not as lively in their movements as compared with animals; yet they too, are able to adapt themselves to their surroundings. Young stems, for instance, are sensitive to light and bend towards a source of light. Some climbing plants produce slender, spirally-coiled structures, called tendrils, which are sensitive to contact and twine around a support.



Tendril (t.) of the Melon

It is very important that living things have the power to respond to external stimuli for by doing so, they are able to find the most suitable conditions which their surroundings permit.

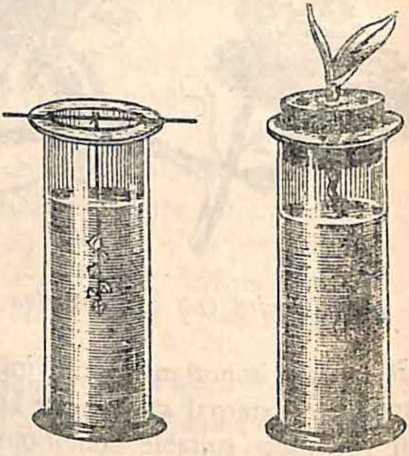
Living things breathe. A new-born baby must be able to breathe from the moment it is born. If it does not breathe, it is smacked and made to cry. When it cries, air is drawn into its little lungs it breathes, and its life is saved. From tiny creatures such as ants to the world's biggest living things, the trees, Nature has made no exception — every living thing must breathe in order to live. Parents do not teach their young how to breathe for it is something that every living thing knows how to do from the time it enters the world.

As we learn more about the various living things about us, we shall find out how breathing is accomplished and the important part it plays in the lives of animals and plants.

Living things feed. All living things, be they plants or animals, feed in order to live. Plants obtain their food from the soil and air. Animals spend most of their lives searching for food. Some animals feed entirely on the flesh of other animals. They are called carnivorous animals. Other animals feed entirely on plants. They are called herbivorous animals. A third group of animals feed on both plants and the flesh of other animals. They are called omnivorous animals. One of the results of taking in food is that growth takes place.

Living things grow. From out of a tiny tamarind seed comes a seedling which continues to grow until it is a huge tamarind tree. A kitten grows into a big cat.

A few non-living things



*To show the contrast between crystal and plant growth. Left: the thread hangs in a saturated solution of alum. Right: the roots of the seedling are in a food solution.**

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* Food solution: potassium nitrate ·25 gm., magnesium sulphate ·25 gm., calcium nitrate 1 gm., potassium phosphate ·25 gm., iron chloride — a trace, dissolved in 1,000 c.c. of distilled water.

may also be said to grow. Hang a thread of cotton in a saturated solution of alum. Soon alum crystals come out of solution and form on the thread. As the water from the solution evaporates, more and more alum comes out of solution and the crystals increase in size. A snowball is another example of a non-living thing that can be made larger by the addition of more of the substance of which it is made.

The difference, however, between the growth of living things and non-living things is in the method of growth. In the case of non-living things, growth takes place by the addition of more of the same kind of material from the outside. But in the case of living things, the food taken in is changed completely into living matter and as a result growth takes place within their bodies.

Living things get rid of waste substances. Some of the food plants and animals take into their bodies is of a useless nature. It is essential that such waste matter be removed. All living things employ a number of ways for getting rid of substances for which they have no use.

Living things reproduce. The power of reproducing young ones similar to themselves and passing on life to their young ones is an important characteristic of living things. By reproduction the world is kept populated with plants and animals.

A stone can be smashed into a number of smaller pieces, and, as a result, the original stone loses its shape and size. A living thing such as a cat, however, gives birth to a number of kittens and having done so, retains its original appearance.

From what has been said, therefore, we can name a thing as living if it moves, responds to external stimuli, breathes, feeds, grows, gets rid of waste substances and reproduces young ones like itself.

Things to make and do

Outdoors:

1. Watch a worm, a butterfly, a fish, a frog, a snake and a monkey, and describe the motions of each.
2. Observe the motions made by the plants in your garden.
3. Make a list of instances where plants make responses to stimuli in order to protect themselves.
4. Name the plants in your garden which reproduce themselves by ways other than by producing seeds.

For your wall newspaper:

Collect suitable pictures to illustrate this chapter.

In your note-book:

Make a list of the differences between a motor car and a human being.

Living or non-living:

Arrange the following in two columns under the headings, LIVING THINGS and NON-LIVING THINGS.

1. Aeroplane. 2. Shell. 3. Donald Duck. 4. Mushroom. 5. Rust. 6. Sea-weed. 7. Moss. 8. Teddy Bear. 9. Snapdragon. 10. Clock.

13

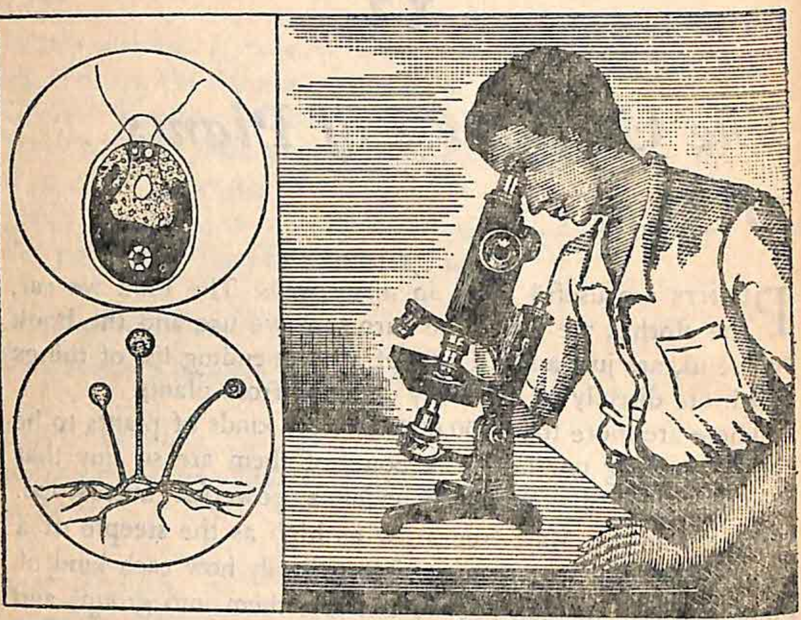
The Usefulness of Plants to Man

PLANTS are useful to us in many ways. The food we eat, the clothes we wear, the furniture we use and the book before us, are just a small part of a never-ending list of things which are directly or indirectly obtained from plants.

There are more than 300,000 different kinds of plants to be found growing on the earth. Some of them are so tiny that they can only be examined under a powerful microscope. Others, like the Mast tree grow as high as the steeple of a church. We will find it impossible to study how each kind of plant is useful to man but we can sort them into groups and learn how each group is useful to us in our daily lives.

Scientists have found that plants can be arranged, according to similarities in their form and structure, into four large groups: Thallus plants, Moss plants, Fern plants and Seed-bearing plants.

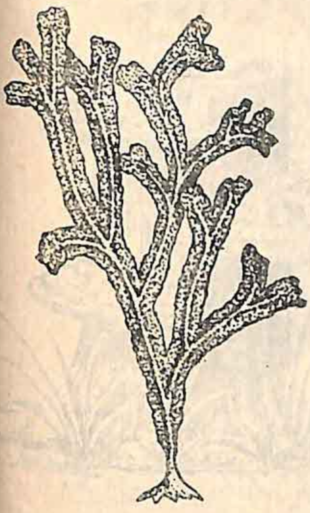
Thallus plants. The plants that are placed in this group are the simplest kinds of plants known. They have no roots, stems, leaves or flowers. Some of them, called Algae, have chlorophyll and can therefore make food for themselves. Others, called Fungi, do not have chlorophyll, and are forced to live on ready-made food which can be obtained from plants and animals. Let us consider each of these two kinds of thallus plants separately and see in what way they are of benefit to us.



Using the Microscope
Top inset: A fresh water alga. Bottom inset: A mould.

The algae are found in fresh water and in salt water. Most of the fresh water kinds are so small that a powerful microscope is needed to examine them; while some of the salt water kinds, known as seaweed, are many hundred feet long.

As you already know, animals are completely dependent, directly or indirectly on the food which plants are able to manufacture in their leaves. Water animals are similarly dependent on the food manufactured by water plants. The algae are eaten by tiny water animals. These tiny water animals serve as food for the larger fish which in due course appear on our dining tables.



A seaweed

The plants grouped together under the name of fungi include the moulds, the yeasts, the bracket fungi and the mushrooms.

Certain moulds are added to cheese to give it a delicious flavour. A 'wonder drug' called Penicillin, which is used by doctors all over the world to cure diseases, is obtained from a mould. A single-celled fungus, called yeast, is used to make bread rise. Bracket fungi hasten decay and thus prevent our forests from becoming choked by dead plants. Many kinds of mushrooms are edible.

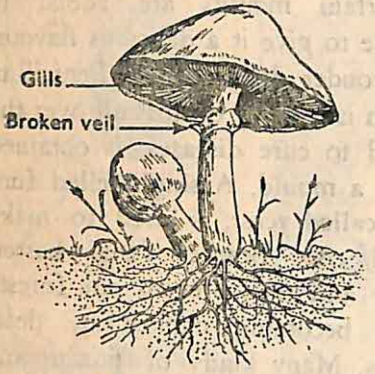
Moss plants. These are small green plants with leaves and stems, but with no roots, or flowers. They grow in a variety of places, thriving wherever there is plenty of moisture. You are sure to find them growing on rocks and old walls during the monsoon months.

Moss plants help to build up soil on rocks. When those plants that are growing on a rock die, their decaying remains accumulate in the crevices of the rock, mix with the dust and crumbling rock particles that are already there, and begin a soil. As more moss accumulates, the soil becomes richer and holds more moisture. After some years, larger

A moss

plants are able to grow on the rock and take their nourishment from the soil thus formed.

Fern plants. These are green plants with roots, stems and leaves, but like the previous two groups have no flowers. They grow best in moist, shady locations.



Mushrooms

Bracket fungi

Ferns are valued for their beautiful foilage and are usually grown in gardens. Apart from being grown for ornamental purposes, they are of little use to man.

Seed-bearing plants. The plants in this group reproduce their kind by means of seeds. Generally speaking, these plants have well-developed roots, stems and leaves.

We have read in Book IV how green plants manufacture more food than they require for their own use. The surplus food is stored in one or more of several places — roots, stems, leaves, fruits or seeds. It is chiefly this reserve food which men and animals use for their own needs.

A fern

Many textiles, such as cotton and linen are made from plant fibres. One of the most important plants in this connection is the Flax plant. Flax fibres are used for making linen, canvas, twine, thread, and even writing paper.

Rubber obtained from the milky juice of the Rubber tree finds a number of uses in everyday life.

The timber of many forest trees is of great importance in the construction of buildings and furniture.

Medicines, oils, paints, perfumes, dyes, gums, tobacco, beverages, chocolate, sugar, spices and a great many other things are obtained from plants.

Although thousands of useful products are obtained from plants, it is not for this reason alone that we cherish them. The beauty of their flowers and the grace of their form will always make us love them and study them with lasting interest.

Things to make and do

Visit the countryside:

Survey a village with the intention of finding out how the inhabitants of the village depend on the plants around them. Take photographs, collect specimens and make records during the survey.

Cutting down trees

Gathering ripe tobacco leaves

Picking young tea shoots

Collecting cocoa pods

Plants and Man

Transplanting young rice plants

Picking cotton

.Tapping rubber trees

Cutting sugar-cane

Plants and Man

For your wall newspaper:

1. Write out neatly the rough notes which you made while at the village.

2. Try to arrange the photographs taken during the survey in the form of a picture story.

3. Mount on your wall newspaper the pressed specimens of plants collected during the survey.

In your note-book:

Write an account of the usefulness of plants and their products in one day of your life.

Fill in the blanks:

Choose the correct words from this list and use them to fill in the blank spaces:

Pepper, spinach, moss, cocoa, quinine, carrots, cabbage. thallus, beetroots, mustard, opium, potatoes, rice, fern, castor. asparagus, seed-bearing, coffee, oranges, coconut. wheat. bananas.

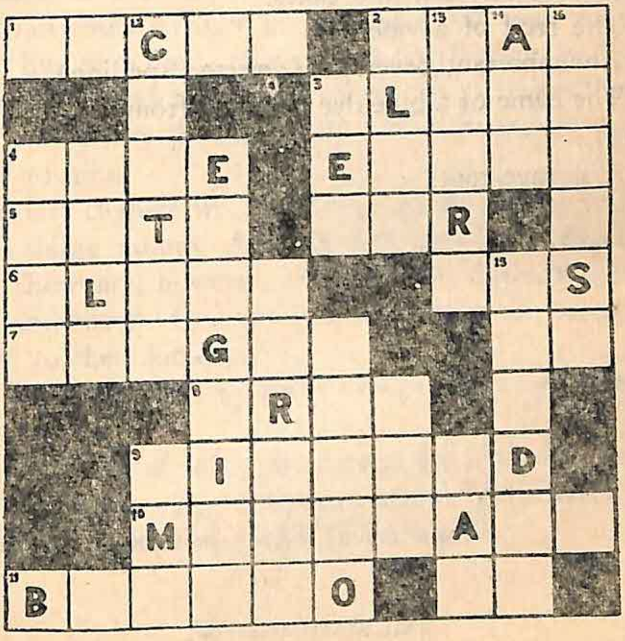
All plants can be arranged into four large groups. The —— plants have no roots, stems, leaves or flowers. The —— plants have no roots or flowers but have leaves and stems. The —— plants have roots, stems and leaves, but no flowers. The —— plants reproduce by means of seeds. The plants in the last group are very useful to us.

Many plants are direct sources of our food supply We eat roots such as —— and ——, stems such as —— and ——, leaves such as —— and ——, fruits such as —— and ——, and seeds such as —— and —— Besides providing us with food the products obtained from plants are many and varied. Oils such as —— oil and —— oil, beverages such as —— and ——, condiments such as —— and ——, drugs such as —— and ——, are all obtained from plants.

A crossword puzzle:

CLUES ACROSS:

1. Chocolate is made from the seeds of this plant.
2. A tasty, yellow fruit.
3. An edible fruit. Its colour changes from green to yellow and finally to red as it ripens (jumbled spelling).
4. Gunny bags are made from the fibres of this plant.
5. A tall palm found growing in desert regions.



6. It is dried as a spice and used to flavour our food.

7. A rhizome.

8. The seeds of this plant are eaten uncooked.

9. The name of the oil which is obtained from the seeds of the flax plant. It is used in cooking.

10. The wood of this tree is used to make furniture.

11. The stem is used for scaffoldings and scout staves.

CLUES DOWN

12. The fibre of this plant is one of the most valuable of all plant products.

3. First found in a pod, then in a stew.

2. It is usually put into cakes.

13. The fruit of a vine.

14. An important beverage (reversed spelling).

15. The name of a blue dye obtained from a plant (reversed spelling).

16. A storage root.

14

The Usefulness of Animals to Man

THROUGH the centuries man has tried to make himself master of most of the animals in the world. Some of them are trained to use their strength in his service, and some are reared to supply him with food and materials for clothing. But besides those animals which man uses to serve his purposes there are thousands of others that indirectly prove themselves to be of great use to him.

In the last chapter we learnt that plants can be arranged into four large groups. Animals, too, can be arranged into groups. There are, however, over 800,000 different kinds of animals, and about 14 groups into which they can be arranged according to their kinship.

Here we will study only those groups which are important to man.

Before dividing animals into groups we must first separate the animals possessing backbones, called Vertebrates, from those without backbones, called Invertebrates.

The Invertebrates

Among the Invertebrates are the Annelid worms, the Molluscs, and the Arthropods.

Annelid worms. The animals in this group have their bodies divided into a number of rings. If you like to go fishing you are sure to have made the acquaintance of at least one member of this group. The earthworm enjoys a wide reputation as being good bait for fish. However, serving as fish bait, is not, by any means, the chief importance of the earthworm to man.

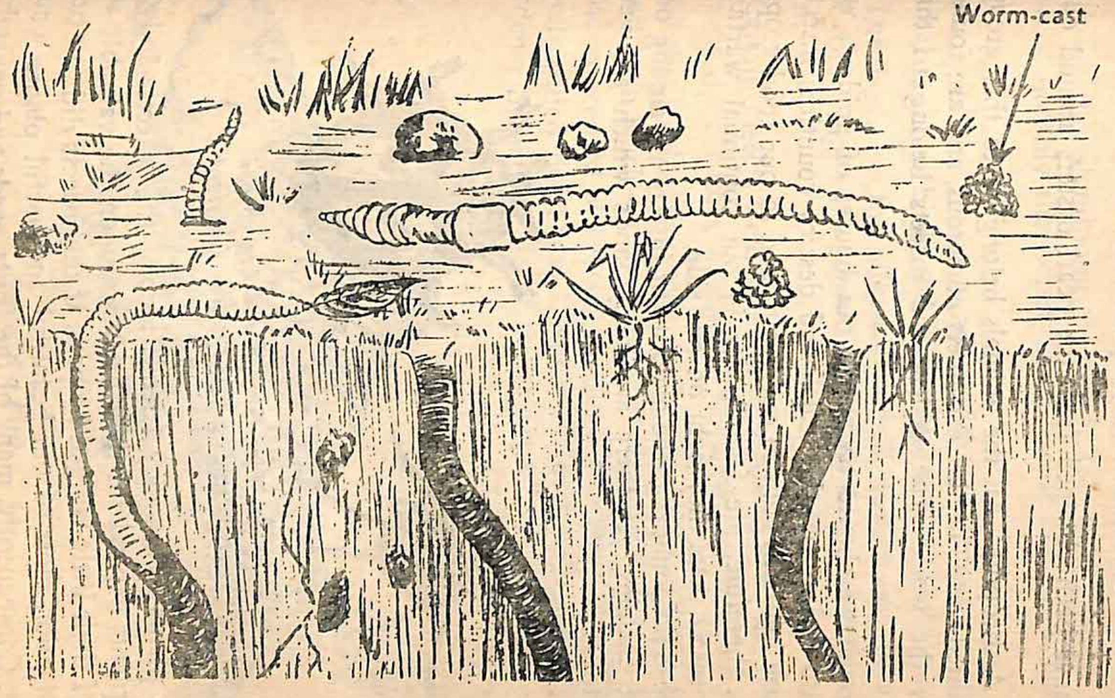
Earthworms may be found living in burrows wherever the soil is moist. They are Nature's own cultivators of the soil. Leaves, grass, stems and rubbish are eaten by them as they ceaselessly burrow their way through the soil. As a result of this, the soil becomes loose and porous so that air and water can enter and plant roots can penetrate more easily. Furthermore, earthworms pull underground fragments of rotting vegetation which, after passing through their bodies, are changed into rich humus.

Molluscs. Animals, like cockles, mussels, clams, scallops, oysters, and snails which have a shell covering their soft, slimy bodies belong to the mollusc group.

Many molluscs, such as mussels. clams, scallops, and oysters are prized as food. The shells of certain molluscs are used for the manufacture of buttons and other articles that are used to ornament the home. Oysters are well known as being the source of precious pearls. Some of the best pearls in the

Molluscs

Oyster *Mussel*



How earthworms live

world have been obtained from the pearl oysters around our coasts.

The Arthropods. All the animals belonging to this group have jointed feet. They are extremely numerous, and are found all over the world. The spiders and insects belong to this group.

Although we should try to rid our houses of spiders, we must also realise that they catch and destroy countless insects which are injurious both to our health and to our food crops. Spiders, therefore, are friends, for in our continual warfare against insect pests they fight on our side.

There is no doubt that the majority of insects are among our greatest enemies, yet there are many kinds which are very useful to us.

Left: Mrs. Spider and her cocoon
Right: The Six-spotted Ladybird

The plants have many friends among the insects. Indeed, many plants depend for their existence upon the valuable services of their little winged helpers. If the insects did not help in pollination most of our beautiful and useful plants would die out. Consequently, many of the fruits, seeds and vegetables we eat would be no longer available.

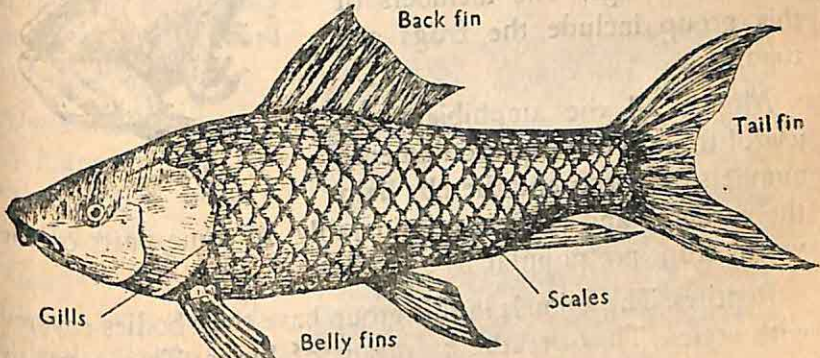
From the standpoint of food, the products of certain insects, notably the honey made by the bees, is very important.

Many of the insects serve as food for a large number of animals such as birds and fish, which are eaten by us.

The larva of the silkworm moth weaves fine threads of silk. Breeding silkworms' is an important occupation in the East.

Certain insects yield products that are used in the manufacture of dyes, paints, medicines, lacquer, and shellac.

In the garden you will see a very small orange-coloured insect with black spots on its back called the Ladybird. It helps those concerned with the growing of plants by eating tiny insects called plant-lice. Dragon-flies and wasps also help the gardener by getting rid of insect pests.



Parts of a Fish

The Vertebrates

The Vertebrates are divided into five large groups. the Fishes, the Amphibians, the Reptiles, the Birds and the Mammals.

Fishes. The animals in this group usually have two pairs of fins. They are able to breathe air dissolved in water by means of gills.

Thousands of people along our coasts earn their living by catching and selling fish. Fresh-water fish are also in great demand.

Amphibians. In this group are found those animals which have two stages in their life-history. They begin their lives in water and breathe by means of gills. When they reach the adult stage, however, they change to an existence on land and breathe by means of lungs. The members of this group include the frogs and toads.

A Frog

Almost all the amphibians are useful to us. They capture immense numbers of insects and thereby help the gardener and farmers considerably. In some parts of the world frogs are popular as a food.

Reptiles. The animals in this group have their bodies covered with scales. They breathe by means of lungs. This group is made up of such animals as snakes and lizards.

Most snakes are of great help to the farmer, since they feed n large numbers of mice and similar pests that are extremely estructive to grain, fruit and vegetables.

The Garden-Lizard

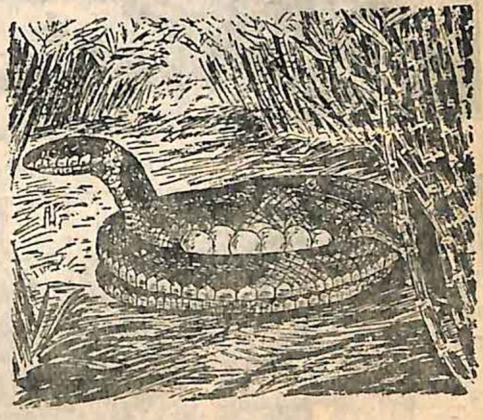
The smaller lizards play a very useful part in the scheme of life by helping to keep down large numbers of insect pests. The skin of larger lizards, such as crocodiles are used for making hand bags, shoes, belts and suit-cases.

Birds. These animals have their bodies covered with feathers. Practically all of them are an important and highly beneficial group of vertebrates.

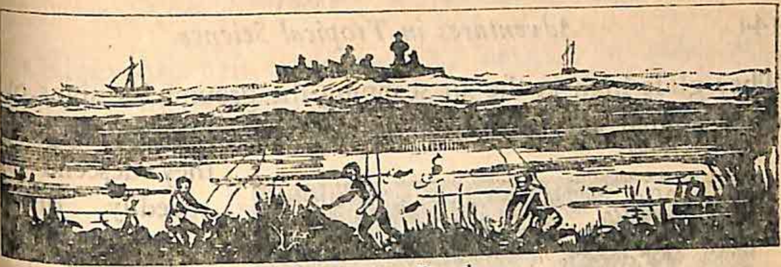
A very large number of birds feed entirely or partly on insects nd thus rid us of pests hat destroy crops and arry diseases.

Owls and Hawks destroy many of the farmer's enemies such as ats and mice.

Crows, Kites and Vultures help to get rid of dead animals by acting as scavengers. The Vultures are especially useful in this respect.

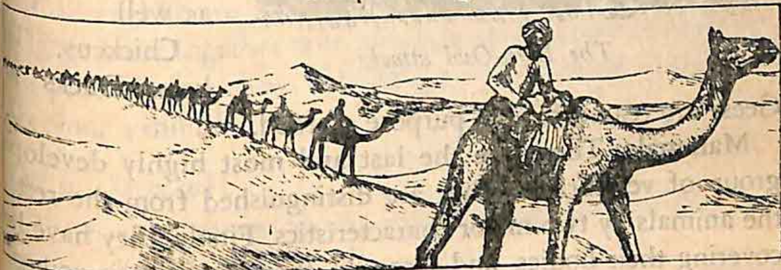


The Wolf-Snake

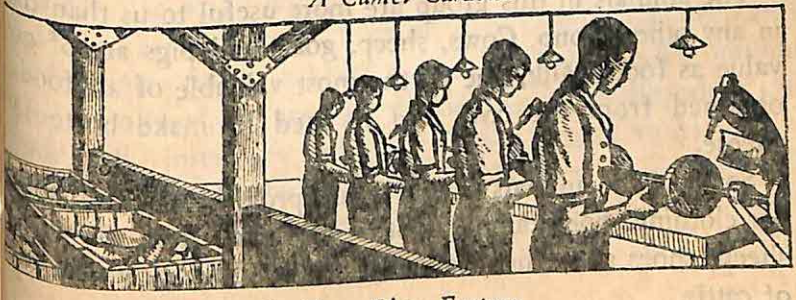


Fishing for Pearls

Sheep-shearing

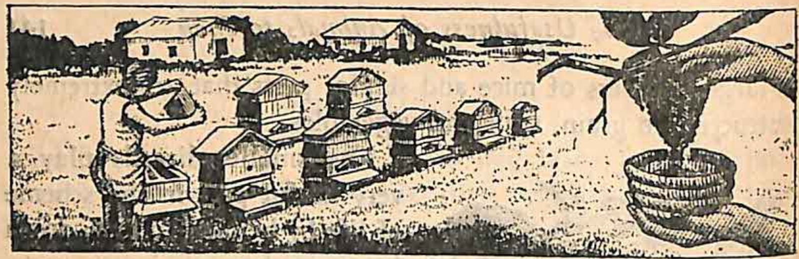


A Camel Caravan



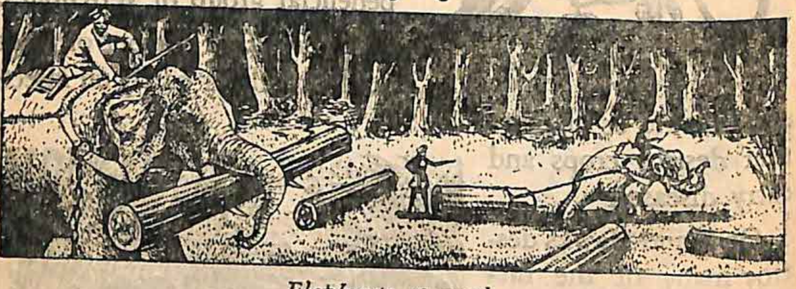
Inside a Shoe Factory

Animals and Man

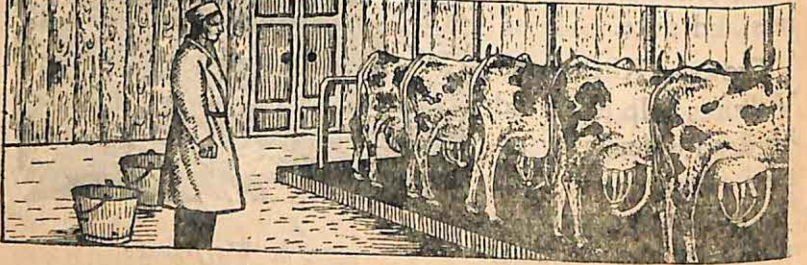


A Bee Farm

Ploughing



Elephants at work



A Modern Dairy Farm.

Animals and Man

They glide high in the air scanning the ground for signs of a dead animal on which to feed. When they spy a carcass they descend and speedily dispose of it.

The Barn-Owl attacks

Although bees, butterflies and other insects are the chief agents for pollination, birds such as the Sun-bird and others do their share of the work as well.

Chickens, Turkeys, Ducks and Geese are reared for the purpose of food.

Mammals. These are the last and most highly developed group of vertebrates. They are distinguished from the rest of the animals by two major characteristics. Firstly, they have hair covering their bodies, and secondly, they suckle their young.

The animals in this group are more useful to us than those in any other group. Cows, sheep, goats and pigs are of great value as food. Milk, one of the most valuable of all foods is obtained from the cow and is used to make butter and cheese.

Some of the animals in this group provide us with materials for clothing. For example, clothes are made from the wool of sheep; shoes and other leather goods are made from the hides of cattle.

Certain mammals can serve their masters in many ways. Bullocks, Horses, Camels, and Elephants are taught to carry loads and do other useful work for man.

Things to make and do

In your neighbourhood:

What are the industries in your town which depend for their existence on the products of animals?

For your wall newspaper:

Obtain pictures of animals which are of use to man and paste them on your board.

Have an exhibition:

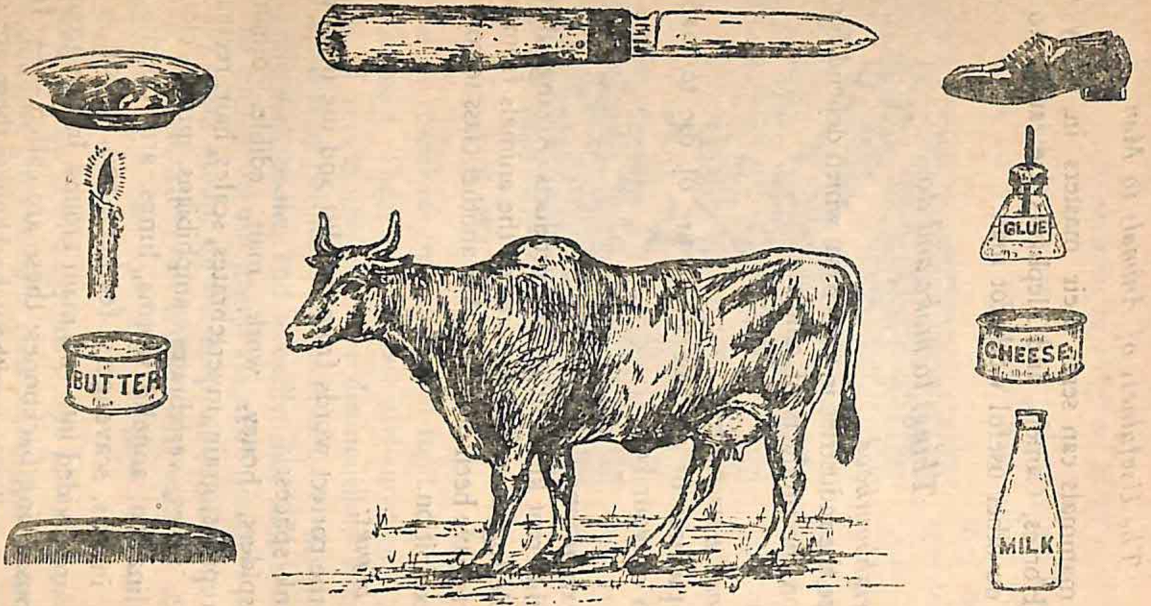
Collect different kinds of animal products. Arrange them on a large table together with pictures of the animals from which the products have been obtained. Ask another class to come and see your exhibition.

Fill in the blanks:

Choose the correct words from this list and use them to fill in the blank spaces:

birds, spiders, honey, work, man, edible, ornaments, molluscs, reptiles, grain, invertebrates, scales, hair, recreation, earthworms, fishes, vertebrates, amphibians, profit, clothing, crops, pollination, annelid worms, lungs, arthropods, gills, food, silk, insects, scavengers, feathers, soil, suckle.

Animals are divided into two main groups. In one group are all those possessing backbones; these are called —— In the other group are all those without backbones; these are called



Things we get from the Cow

——. Each of these groups is further sub-divided into smaller groups.

The —— have their bodies divided into a number of rings. The —— may be taken to represent the group. They help man by cultivating the ——. The —— have a shell covering their bodies. Many of them are ——, and —— are made from their shells. The —— have joined feet. In this group are the —— and ——. Spiders help us by destroying large numbers of harmful insects. Some insects bring about——. —— and —— are products of insects.

The —— live in water and breathe by means of ——. Men catch them for —— and ——. The —— pass part of their life on land and part in the water. They help man by destroying insect pests. The —— have their bodies covered with ——, and breathe by means of ——. The animals in this group help the farmer by killing pests that destroy —— and ——. The —— include all those animals that have their bodies covered with ——. A large number of them eat insects, some of them serve man as ——, and others provide him with ——. Mammals is the group to which —— belongs. They have —— covering their bodies and —— their young. Some of them supply man with food, and materials for ——. Certain mammals can be trained to do —— for man.

In your note-book:

1. Write a brief account of the usefulness of the Cow.
2. State, giving reasons, the group to which each of the following animals belong:

Salmon, Gorilla, Leech, Locust, Salamander, Ostrich, Cowrie, Chameleon.

3. Link each animal with its product:

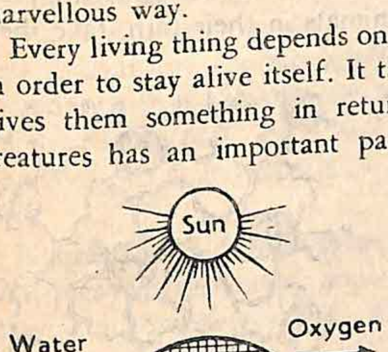
ANIMALS	PRODUCTS
a. Cow	Ivory
b. Mussel	Blankets
c. Sheep	Glue
d. Elephant	Fur coats
e. Fox	Pearl-buttons

15

The Web of Life

Many thousands of different kinds of plants and animals inhabit the earth. Although each kind is different in many ways from every other kind, and appears to be intent on its own affairs, yet its life is woven with that of the others in a most marvellous way.

Every living thing depends on the work of other living things in order to stay alive itself. It takes something from them and gives them something in return. Even the tiniest of living creatures has an important part to play in the vast system of inter-relations and linkages that exists in nature.



What a chlorophyll machine can do

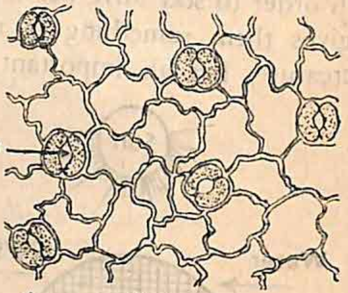
Food. All animal life is wholly dependent on plants for food. Green plants make not only their own food but also enough food for every living thing on earth. They are able to take carbon dioxide from the air, and wate from the soil and use thes substances to make starch This important food is mad in their leaves with the help of chlorophyll and sunlight. Th starch is later taken and stored in various parts of their bodie

Furthermore, plants also take in mineral salts from the soil. By adding these to the food they have already made, they form other food-substances for themselves and for all other living things as well.

Non-green plants, such as the fungi, are unable to make their own food since they lack chlorophyll. They are, therefore, obliged to obtain their food from dead or living things. The fungi that feed on dead things play an important and useful part in the plan of life, for by their activity they bring about decay

From the standpoint of chemistry, living things are built up of elements and compounds. As you have just read, green plants obtain the elements and compounds of which they are made from the soil and air. Animals in their turn, take them in with their food and water.

When plants and animals die, their bodies decay. The fungi decompose the dead bodies of one generation of living things, thereby setting free elements and compounds which go back into the soil and air in forms that can be used over again by the next generation. It is Nature's plan that nothing goes to waste.



A magnified view of a portion of the skin on the under-side of a leaf showing the pores (p)

Interchange of gases. During the process of breathing most of the oxygen is taken from the air that enters the body of a living thing, while the air that passes out contains more carbon dioxide than it had when it came in. Plants, like animals, breathe all the time without ceasing. On the under-sides of their leaves are many tiny pores. Air passes in and out of the plant body through these pores.

During the day the plant factories are working. The chlorophyll machines take the carbon out of the carbon dioxide to make starch and set free the oxygen. Since the oxygen thus set free is far in excess of the plant's requirements for breathing, it passes out of the plant into the air.

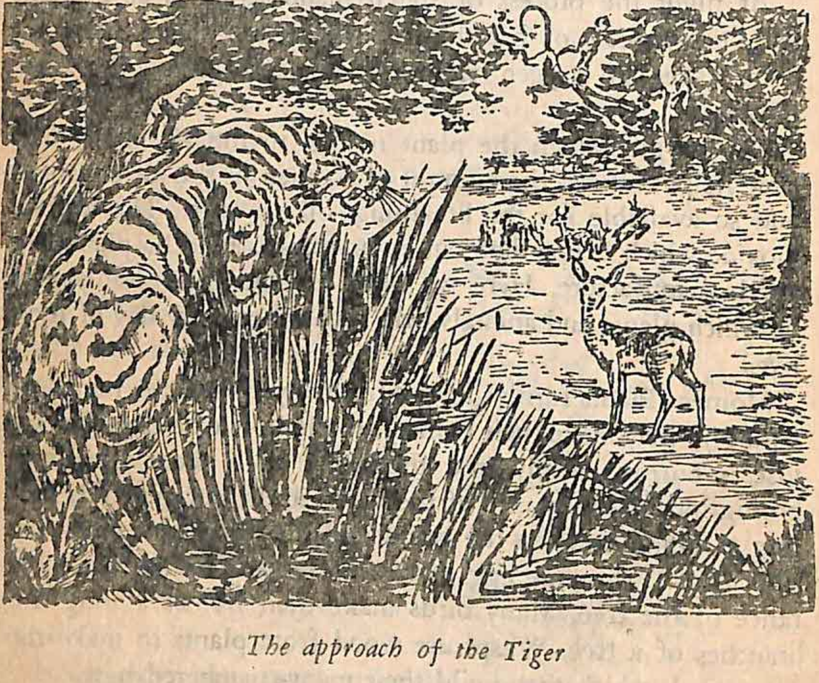
At night the process of starch manufacture is at a standstill; the process of breathing, however, continues. Now the plant takes in oxygen from the air and gives off carbon dioxide.

The oxygen which the plant returns to the air in the daytime helps to keep the amount of oxygen in the air constant, and so available for the breathing of animals. The carbon dioxide which is breathed out by animals is used by plants for starch manufacture. Here we have a wonderful arrangement by which plants and animals help each other every day of their lives.

Homes. Plants furnish homes for many animals. A family of wild pigs may make their home in the hollow of a tree. Certain insects burrow deeply into the trunk of a tree, sometimes boring into the substance of the wood itself, but generally cutting a tunnel between the wood and the bark. Here they lay their eggs. When the eggs hatch, the larvae feed on the substance of the tree. Many birds make their homes among the branches of a tree. Wasps use wood from plants to make the paper with which they build their many-chambered nests.

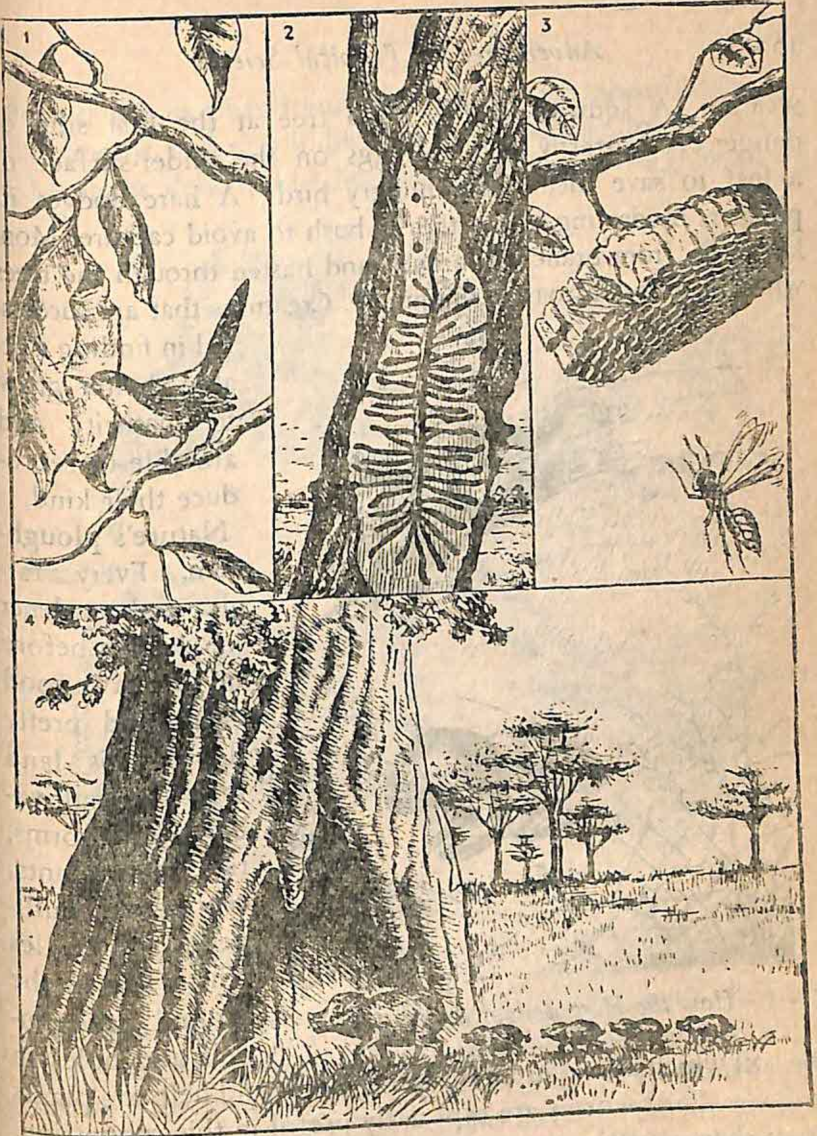
Camouflage. In addition to food, and materials with which to build a home, many of the animals depend on plants to conceal them from their enemies or from their prey. If their general make-up or the colour of their coats are the same as that of the plants in their neighbourhood, they are able to escape observation when the need arises.

Disguise, make-believe, imitation — all these word-meanings are connected with the idea of camouflage. The stripes on the coat of a tiger enable it to follow its prey without being seen. A stick-insect is able to escape detection because it looks like the twig of a plant. These are just a few examples of the many animals that make use of camouflage to help them survive the battle of life.



The approach of the Tiger

Shelter. Many animals seek refuge among the plants to avoid their enemies and to protect themselves from harsh



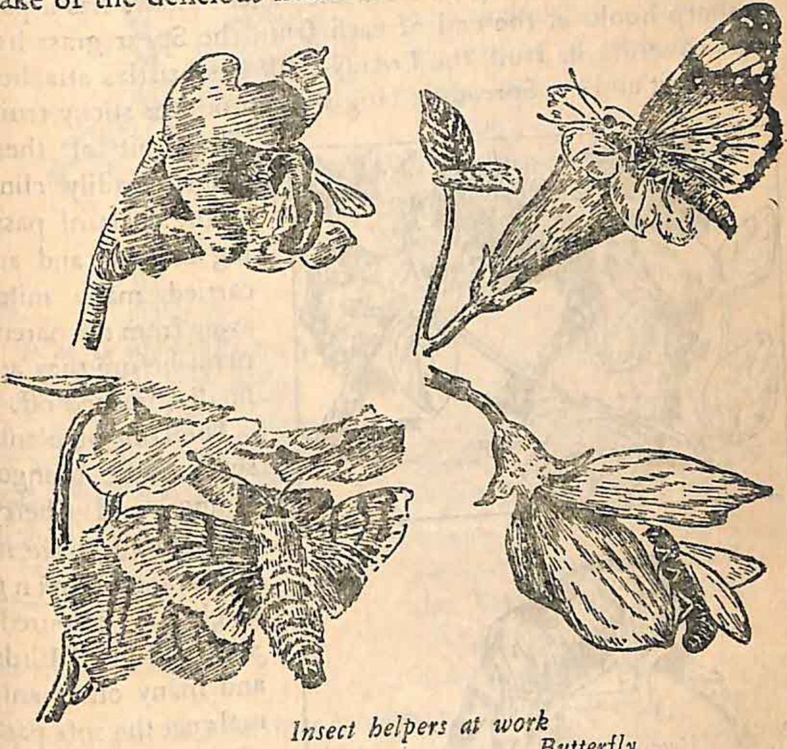
Animal Homes
1. A Tailor Bird and its leafy cradle. 2. Tunnels made by a wood-boring beetle and its young. 3. The Paper houses of the Wasps. 4. Mrs. Pig leads her family home after a busy day in the forest.

weather. A squirrel dashes up a tree at the first sign of danger. A butterfly lays its eggs on the under-surface of a leaf to save them from hungry birds. A hare dodges its pursuers by darting into a thorny bush to avoid capture. Monkeys leap from branch to branch and hasten through the trees when they hear a roar in the jungle. Creatures that are successful in finding suitable shelter grow to maturity and are able to reproduce their kind.

How the Hare dodges its pursuer

Nature's ploughmen. Every farmer and gardener knows that before he can have good crops and pretty flowers his land must be cultivated. Earthworms, rats, rabbits, ants, centipedes, millipedes and beetles which live in the ground make tunnels and holes in the soil which allow air and water to enter and help the plants to grow. Earthworms are especially useful in this connection. They change rotting vegetation into humus, thereby enriching the soil.

Pollination. You have already seen how the bees and the flowers are like hand and glove. Not only bees, but butterflies, moths, and certain birds as well, visit the flowers for the sake of the delicious nectar stored in their flowers. By flying from flower to flower they bring about pollination, helping the plants they visit to reproduce their kind. If you study how the work of pollination is being done in your garden, you will realise the extent to which the flowers and the animals which serve them as pollen carriers are linked together in the web of life.



Insect helpers at work

Bumble-bee
Moth

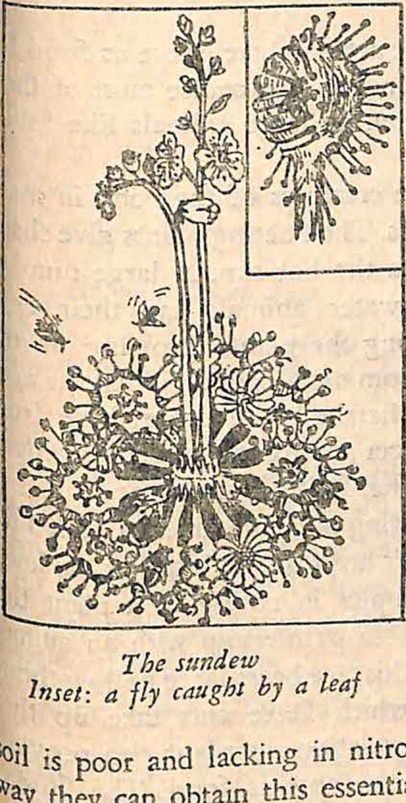
Butterfly
Honey-bee

Seed dispersal. A large number of plants depend entirely on animals for the purpose of dispersing their seeds. The Devil's Claws has burs covering its fruit, the Tiger's Claws has a pair of sharp hooks at the end of each fruit, the Spear grass has hairs covering its fruit, the Prickly-chaff has bristles attached to its fruit and the Spreading Hog-weed produces sticky fruit. The fruit of these plants readily cling to the coats of passing animals and are carried many miles away from the parent plant before they are finally brushed off.

The fruit of plants such as the Mango, Orange and Cherry are very attractive in appearance, being brightly coloured, soft, and juicy. Birds and many other animals eat the soft part of the fruit and scatter the seeds, thus bringing about their dispersal. Seeds that are parts of berries, like the mulberry, or parts of figs, like the Peepul, are also eaten. The precious seeds within the fruit

How the Goat helps to disperse fruit

ave a hard, stony coat, or a thick, tough skin which prevents them being digested. Because of this, the seeds pass unharmed through the bodies of animals as waste material.



The sundew
Inset: a fly caught by a leaf

Insectivorous plants. Although about four-fifths of the air is made up of a gas called Nitrogen, plants are unable to use this element in its free state. They can, however, obtain it from the soil where it exists in the form of compounds. The decaying remains of animals are a rich source of nitrogen. Some plants such as the Sundew, the Bladderwort, and the Pitcher-plant grow in wet, boggy ground where the oil is poor and lacking in nitrogenous compounds. The only way they can obtain this essential element is from the bodies of insects which they entrap.

Inter-dependence of pond life. The plants and animals in a ond are inter-dependent, that is, each depends on the other. The water-plants help to aerate the water and keep it upplied with oxygen. In addition, they absorb the carbon dioxide given off by animal life. The animals, in heir turn, breathe in oxygen from the water and give off carbon dioxide, which is needed by the plants for starch manufacture. In this way the balance of life in the pond is maintained.

Tiny non-flowering plants such as algae, serve as food for many small animals in the pond. In due course most of these animals are captured and eaten by large animals like fishes, frogs and snakes.

Water-plants help the little creatures of the pond in many ways. The floating plants give shade from the hot sun. A large number of water animals lay their eggs among the plants growing at the bottom of the pond. When the eggs are hatched, the babies hide from danger among the tangled greenery.

The Bull's horn Acacia

The Bull's horn Acacia. A tree growing in South America, called the Bull's horn Acacia is one of the finest examples in nature of a plant that lives in partnership with an animal.

This tree bears large hollow thorns in which fierce ants take up their abode. In addition to accommodation the plant also provides a sugary fluid which serves the ants as food. The fluid is found in the young thorns and at the tip of the leaflets.

In return for the hospitality they receive, the ants reward the plant by swarming out and attacking any animal which attempts to feed on the leaves.

In the ways that have been mentioned and in many other ways, the lives of plants and animals are bound up with each other and with man. Without thinking or planning, the wild things of the earth continue leading their natural lives, giving and taking from each other, and helping to produce all the things we need to live.

Things to make and do

In the garden:

Make a study of how the plants and animals in the school garden depend on each other.

For your wall newspaper:

Make two separate sketches to illustrate how plants and animals interchange gases during the day and night.

In your note-book:

Only green plants are able to make food. Animals are forced to go in search of it. They either eat plants or other animals which feed on plants. For example, snakes eat birds. Birds, in their turn feed on insects. Insects, in their turn feed on plants. This relationship related to food getting may be illustrated by a series of food-chains.

plants ——→ insects ——→ birds ——→ snakes

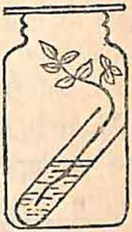
The arrows represent the words 'eaten by'.
Make food-chains for all the animals on a farm.
Example:

plants ——→ mice ——→ cats

At home:

1. Show that plants produce carbon dioxide as follows. Put a leafy twig in a test tube of water and place it in a glass

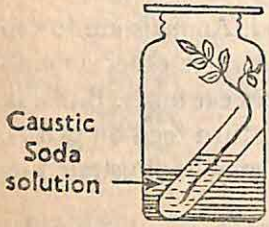
jar. Close the jar with a well greased cover glass and put the apparatus into a dark cupboard. After two days take out the jar and test the gas in it by adding a little lime-water and shaking. The lime-water becomes milky proving that the plant has produced carbon dioxide.


To show that plants produce carbon dioxide

Check your result by repeating the experiment with a dead twig.

2. Show that plants require oxygen as follows.

Take a glass jar and pour some caustic soda solution into it. Put a leafy twig in a test tube of water and place it in the glass jar. Close the jar with a well greased cover glass and leave the appartus in a dark cupboard for about two days.



To show that plants require oxygen.

The carbon dioxide given off by the twig is absorbed by the caustic soda solution and the oxygen in the jar is used up by the twig. The result of this is that when a burning splinter is thrust into a jar it goes out.

Check your result by repeating the experiment with a dead twig.

Fill in the blanks:

Choose the correct words from this list and use them to fill in the blank spaces:

insectivorous, day, soil, air, shelter, oxygen, inter-dependent, concealment, nitrogen, disperse, materials, food, starch, pollination, green, carbon dioxide, dead, cultivate, decomposing.

Plants and animals are ——. Only —— plants are able to make their own food. They make their food from materials found in the —— and ——. Animals obtain their —— either directly or indirectly from plants. Fungi feed on —— animals and plants, —— their food into —— that can be used again by a new generation of living things. The —— returned by plants to the air in the —— is used by animals. The —— breathed out by animals is used by plants for —— manufacture. In addition to food and —— many animals depend on plants for ——. Animals, in their turn, help the plants. Creatures that live underground help to —— the soil. Insects and birds help in ——. Many animals help to —— the seeds of plants. —— plants obtain —— by capturing insects.

16

Our Food, and What Becomes of It

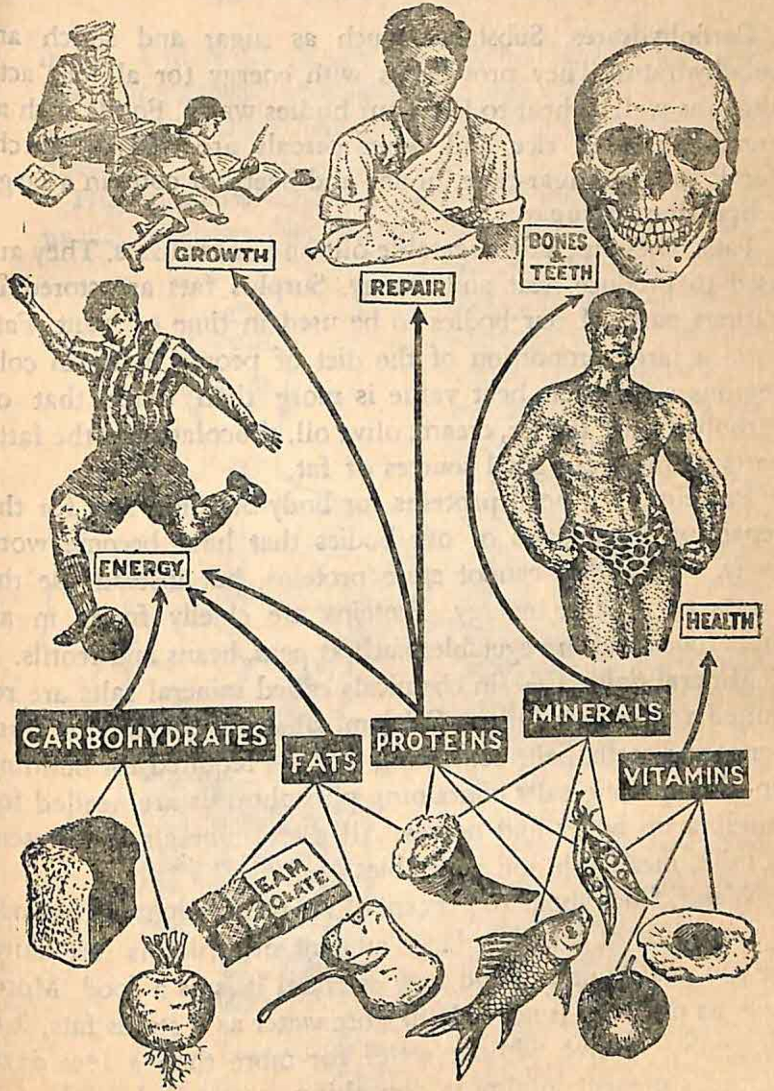
WHILE we are alive our bodies are never completely at rest. Even when we are fast asleep, movements take place continuously within our bodies. In order to move and do work we need a supply of energy. It is for this reason that we eat food. Besides providing us with energy, the heat produced when food is used is sufficient to keep our bodies warm and at a fairly constant level of temperature.

As a result of the work we do, some parts of our bodies become worn out. These parts are replaced by fresh material from our food.

Food is also required to make our bodies grow. In the case of children especially, food is used to make new material which helps them to grow.

Furthermore, certain foods contain substances which protect the body from disease and regulate its healthy working.

Classes of Food. Although foodstuffs are so varied as regards appearance and taste, men of science have split them up into different classes of substances. These substances have different properties and therefore different effects on our bodies. The chief classes of foodstuffs which are essential to life are: Carbohydrates, Fats, Proteins, Mineral Salts, Water, and Vitamins.



Food and its uses

Carbohydrates. Substances such as sugar and starch are carbohydrates. They provide us with energy for all our activities, as well as heat to keep our bodies warm. Foods such as bread, potatoes, rice and other cereals are rich in starch. Foods such as sugar-cane, honey and beetroot contain a large proportion of sugar.

Fats. These include vegetable oils and animal fats. They are used to produce heat and energy. Surplus fats are stored in various parts of our bodies to be used in time of want. Fats form a large proportion of the diet of people living in cold regions since their heat value is more than twice that of carbohydrates. Butter, cream, olive oil, chocolate and the fatty parts of meat are good sources of fat.

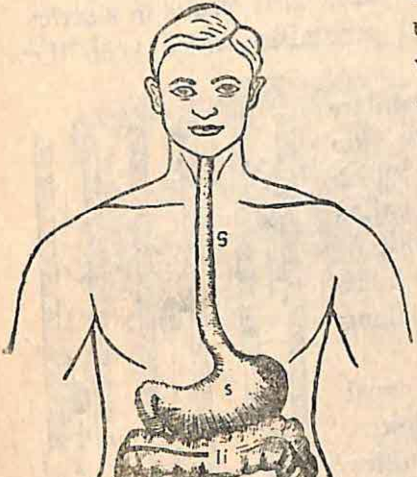
Proteins. We need proteins for body-building and for the repair of those parts of our bodies that have become worn away. Our bodies cannot store proteins, but instead use the excess to produce energy. Proteins are chiefly found in all meat foods and in vegetables such as peas, beans and lentils.

Mineral Salts. Certain chemicals called mineral salts are required for body-building. Calcium salts are essential to form bones and teeth. Salts containing iron are required for building up blood, while salts containing phosphorous are needed for building up bones and nerves. All these minerals are present in milk, meat, fish and vegetables.

Water. Since about 70 per cent of the total weight of the body is composed of water, a large amount of which is lost daily, we can readily understand how essential it is as a food. Moreover, as the body is not able to store water as it stores fats, it is impossible to live without water for more than a few days. Water is present in almost everything we eat and drink.

Vitamins. These substances help in keeping the body in good health. Unless we partake of foods such as milk, eggs, fresh fruit, vegetables, and fish liver oils, which contain minute quantities of these important substances, we will suffer from disease.

Digestion. Before the foodstuffs we eat can be of any use to us it is necessary that they should be reduced to a condition in which they can be utilised. The set of processes which foodstuffs undergo whereby they are converted into substances capable of being absorbed by our bodies is called digestion.



The Alimentary Canal
g, gullet; s, stomach; si, small intestine; li, large intestine; r, rectum; a, anus.

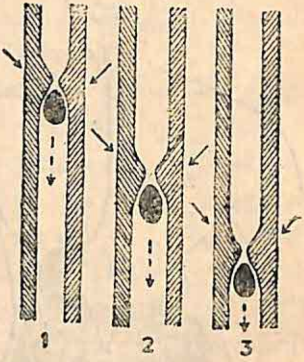
The Alimentary Canal. The food we eat and swallow enters a pipe called the Alimentary Canal. This pipe is about 30 feet long, narrow in some parts and wide in others. Although it is so long and has bulges along its length it is able to fit into our bodies as it is arranged in close coils.

The alimentary canal begins in the mouth and is at first a narrow pipe about six inches long, spoken of as the gullet. This pipe runs down to a bag called the stomach. From the stomach the canal continues as a pipe which is about 20 feet long. It is called the small intestine. This in turn leads into a wider pipe about 5 feet long. known as the large intestine. The last part of the alimentary canal is a short narrow pipe called the rectum. The rectum leads out of the body by an opening called the anus.

The entire length of the alimentary canal is built up of muscular walls. Swallowed food is forced along the gullet and intestines by muscular action. The walls of these pipes contract behind the food and relax in front of it. This results in a series of wave-like constrictions, called peristalsis, which keep the food moving along the canal.

The inner lining of the alimentary canal consists of a soft, delicate skin called the mucous membrane which secretes, or gives out, a fluid called mucous. This fluid keeps the inside of the canal moist and also acts as a lubricant to ease the passage of food along the canal.

As the food is moved along the canal it is mixed with a number of juices. These juices contain minute quantities of substances called enzymes which help to digest the food, though they, like catalysts, remain unchanged at the end.

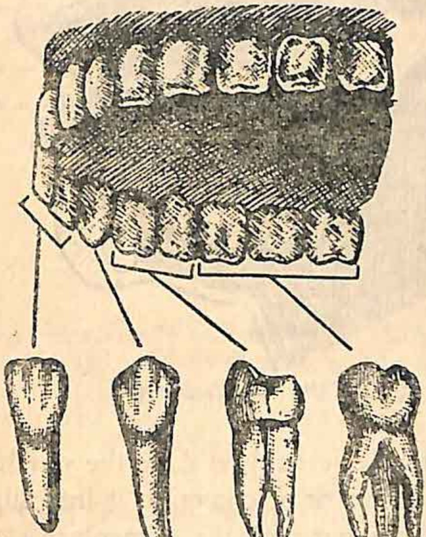


To show how food is squeezed along the alimentary canal

To understand more about the wonderful way our food is broken up into suitable forms for distribution to the different parts of our body, we must imagine that we could follow some food as it journeys along the alimentary canal.

The Mouth. When food is taken into the mouth it is broken up by the teeth into fragments so that it may be readily acted on by the various digestive juices. There are four kinds of teeth for this purpose. The central four of each jaw, called the incisors, are provided with sharp, chisel-like edges meant for biting or cutting the food. Next to these, on either side, is a single tooth with a pointed crown called the canine tooth. It is well adapted for tearing food. Next beyond the canines, is a pair of teeth called the pre-molars. Behind these again are larger teeth with broad, rough surfaces called the molars. The molars and pre-molars help to grind the food.

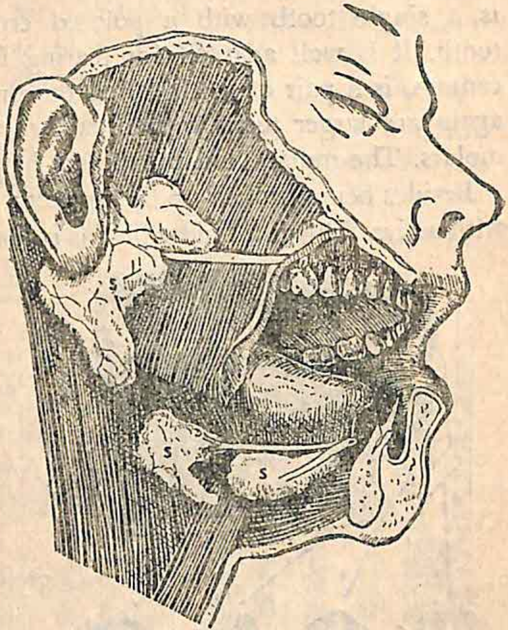
Besides being broken up by the teeth, the food is also mixed with saliva. This is a fluid which is made in the salivary glands. A gland consists of a group of special cells whose work is to prepare a special kind of juice. One pair of salivary glands is situated below and in front of each ear; another pair is found underneath the jaw bone; and the third pair lies just beneath the tongue. Saliva, the product of these glands, passes through tubes from the glands into the mouth. The sight, smell, or taste of food, or even the mere thought of a favourite meal is sufficient to cause the salivary glands to secrete saliva.



Kinds of Teeth
1, *incisor;* 2, *canine;* 3, *pre-molar;* 4, *molar.*

Saliva contains an enzyme, called ptyalin, that acts on the starch present in the food and changes it into a form of sugar. Insoluble starch is thus changed into sugar which is soluble and therefore can be used by the body. Saliva also softens the food, making it easier to swallow.

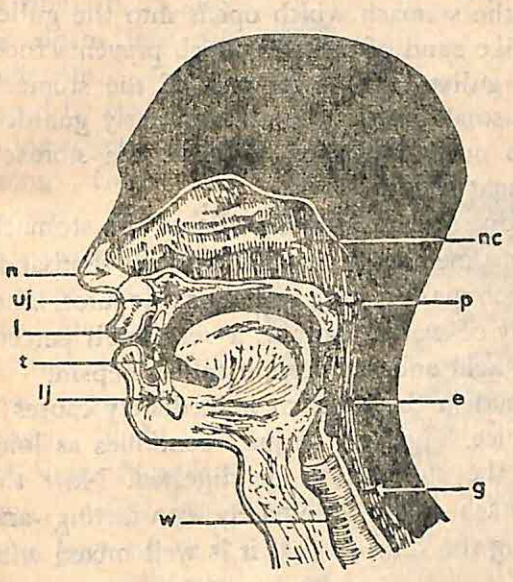
Although saliva is such an important juice some people waste it by spitting constantly. This is a bad habit and must be avoided as it spreads germs and disease.



The Salivary Glands (*s*)

It is very necessary that food should be chewed well in the mouth before it is swallowed. Unless this is done the starch in it remains undigested and the work of changing it into sugar will have to be done by other parts of the alimentary canal which have their own work to do. Moreover, hard pieces of food may cause trouble in other parts of the canal and this is likely to cause indigestion.

Once the food has been prepared for swallowing it is rolled into a ball by the tongue and forced down the throat into the gullet. The picture on page 169 shows two passages going down from the mouth. The passage in front is for air and is called the windpipe, while the passage behind it is the gullet. During the act of breathing, the gullet is closed by a flap of skin which works like a trap-door, called the epiglottis. When food is swallowed, however, the epiglottis swings away from the gullet opening it and at the same time closing the windpipe. Sometimes the food gets caught in the epiglottis or gets into the windpipe. This immediately results in a fit of coughing which is the body's way of trying to dislodge whatever is causing obstruction. The food having entered the gullet is forced along by peristalsis.



Longitudinal section of nose and throat
n, nostril; uj, upper jaw; l, lip; t, tooth; lj, lower jaw; w, windpipe; nc, nasal cavity; p, palate; e, epiglottis; g, gullet.

The Gullet. It is a straight pipe connecting the mouth to the stomach. The passage of food through the gullet takes only a few seconds and no changes occur in the food.

The Stomach. This is a muscular bag meant for the temporary storage and partial digestion of some food. Here food may stay from one to four hours depending on its nature. During this time it is acted upon by digestive juices.

The upper end of the stomach which opens into the gullet is guarded by a ring-like band of muscles which prevents food from re-entering the gullet. The lower end of the stomach which opens into the small intestine is also similarly guarded by muscles which do not allow food to leave the stomach until the proper moment arrives.

As you have already read, the inner walls of the stomach are lined by the mucous membrane. In this there are thousands of minute glands which make a juice called gastric juice. This juice, consisting chiefly of water, contains a very small percentage of hydrochloric acid and an enzyme called pepsin.

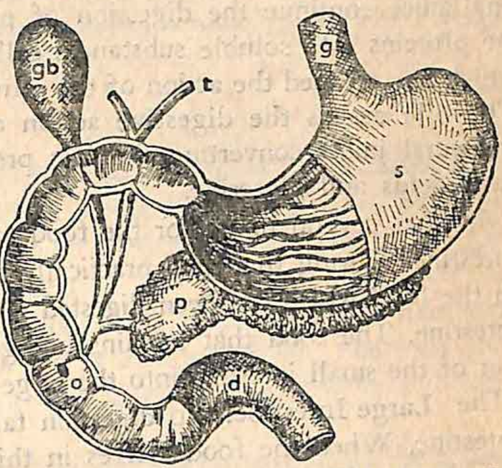
The presence of food in the stomach immediately causes a secretion of gastric juice. The flow of juice continues as long as there is food in the stomach to be digested. Now the muscles of the stomach begin alternately contracting and relaxing, thus churning the food so that it is well mixed with the gastric juice.

The pepsin in the gastric juice cannot act on the food unless it is in the presence of hydrochloric acid. Its work is to split up the protein part of the food into soluble compounds called peptones.

Saliva swallowed with the food continues its action in the stomach.

When the food has become partly digested and changed into a soft, semi-fluid mass the ring of muscles which all this time had prevented the food from entering the small intestine, now begins to open. With every contraction of the stomach muscles a small quantity of food spurts into the intestine. After each spurt the band of muscles contracts, closing the opening.

The Small Intestine. The first loop of the small intestine, called the duodenum, receives the partially digested food from the stomach. A tiny tube opens into the duodenum. It is formed by two tubes uniting together, one coming from the pancreas and the other from the liver. The pancreas is a large gland which is situated in the curve between the stomach and the duodenum. It makes a juice called pancreatic juice which it secretes whenever there is food in the duodenum. The liver is another gland. It lies almost opposite the pancreas in such a way as to partly cover the stomach. In addition to its other work, the liver continually makes a juice called bile. The bile is stored in a small bag known as the gall-bladder. When there is food in the duodenum the gall-bladder gives up its contents.



To show where the juices of the liver and pancreas enter the duodenum
g, gullet; s, stomach; gb, gall-bladder; t, tubes which convey bile from the liver; p, pancreas; o, opening of tubes from liver and pancreas; d, duodenum.

The food is thus mixed with the pancreatic juice and bile as it arrives in the duodenum. Besides these two juices the food is also mixed with intestinal juice which is secreted from numerous glands in the mucous membrane of the small intestine.

Each of these juices has its own work to do. The enzymes in the pancreatic juice together with the enzymes in the intestinal juice continue the digestion of proteins. They split up the proteins into soluble substances called amino-acids. Starch which has escaped the action of the saliva is changed to sugar. The bile assists the digestive action of the pancreatic and intestinal juices converting the fats present in the food into fatty acids and glycerine.

It takes several hours for the food to pass along the small intestine. During this time practically all the useful material in the food which has been digested is absorbed by the small intestine. The food that remains undigested, however, passes out of the small intestine into the large intestine.

The Large Intestine. No digestion takes place in the large intestine. When the food arrives in this pipe it is in a very liquid state. The last remnants of nourishment together with water are now absorbed and the waste matter which remains, called fæces, gradually becomes solid. The journey of the waste material through the large intestine takes several hours. Finally it is passed into the rectum where it collects until it is ejected through the anus.

It is important to get rid of this waste at least once daily, or constipation, which is the cause of much illness, will result.

Things to make and do

At home:

Make a list of foods you eat in a single day and say what classes of foodstuffs they contain.

For your wall newspaper:

Cut out coloured pictures of different kinds of foods from old magazines, and arrange them to make a food chart similar to that shown on page 163.

Prove it yourself:

1. When we swallow our food it does not simply fall down our gullet, but is squeezed along by peristalsis, a muscular action over which we have no control. You can prove that this is so by a simple experiment.

Lay a cushion on the floor next to the wall and stand on your head. Try eating a biscuit in this position. The food you swallow is pushed along against the force of gravity and goes up to your stomach.

2. Starch is converted into sugar in the mouth by the action of an enzyme called ptyalin which is present in the saliva. If you chew a piece of bread you will find that although at first it does not taste sweet, yet at the end of about half a minute it tastes quite sweet.

Fill in the blanks:

Choose the correct words from this list and use them to fill in the blank spaces:

peptones, intestinal, proteins, rectum, pepsin, starchy, vitamins, meat, fatty acids, water, six, bile, large, churned, alimentary canal, small, absorbed, fats, sugary, ptyalin, amino-acids, glycerine, gullet, starch, peristalsis, butter, carbohydrates, vegetables, sugar, three, gastric juice, mineral salts, saliva, teeth, pancreatic.

There are —— classes of foodstuffs. —— and —— provide us with heat and energy. The former is found in —— and —— foods, while the latter is found in —— and cream. ——, found in all —— foods, and —— keep our bodies in good repair. —— are required for body-building. —— must be drunk at frequent intervals to replace the large amount lost daily. Absence of —— from our diet result in ill health.

Digestion is done in the ——. Food is passed along this canal by ——. In the mouth the food is broken up by the —— and acted upon by the ——. The —— in the saliva changes starch to ——. Swallowed food passes down the —— to the stomach. In the stomach the food is —— and mixed with —— The —— in the gastric juice splits up proteins into ——. Digestion continues in the —— intestine. Here the food is acted on by —— juices. The —— and —— juices split up proteins into ——, and —— is changed into sugar. The —— helps to convert fats to —— and ——. All the useful food which has been digested is —— and the undigested food is passed into the —— intestine. Here water is absorbed. The waste matter is sent into the —— from where it is passed out in due course.

In your note-book:

1. Draw simple outline sketches of the pictures on pages 165 and 169. Label each drawing.

2. Complete this table.

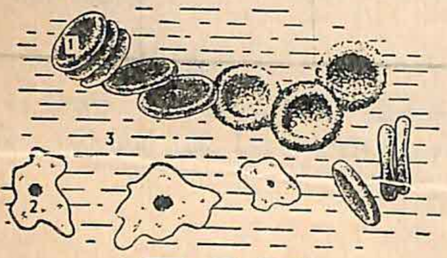
Digestive Juice	Gland which secretes the juice	Part of Alimentary canal into which the juice flows	Actions on food
Saliva			
Gastric juice			
Pancreatic juice			
Bile			
Intestinal juice			

17

Our Amazing Circulatory System

WITHIN each one of us is the most remarkable transport system in the world. It consists chiefly of a central pump and a system of pipes through which blood is pumped. Silently and automatically, working day and night, it ventilates, supplies food and removes waste. Press the fingers of one hand on the wrist of your other hand and you will feel the blood surging through one of the highways of the system.

The Blood. If a drop of blood is examined under a powerful microscope it will be seen that it is not the sticky, red liquid it appears to be. Actually it consists of a pale, yellow liquid called plasma, in which float millions of living cells. Some of these cells, called corpuscles, are of two kinds: red corpuscles and white corpuscles.

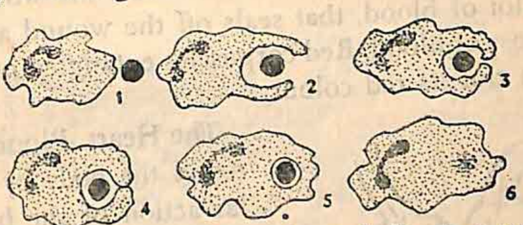


Blood Corpuscles
(highly magnified)
1. *red corpuscles*; 2. *white corpuscles*; 3. *plasma.*

The Red Corpuscles. These are minute discs, thinner at their middles than at their edges. They contain a chemical which is red in colour called haemoglobin. The enormous numbers of these corpuscles in the blood make it appear to be red in colour.

Haemoglobin is capable of uniting with oxygen and transporting it from the lungs to all parts of the body. When combined with oxygen, haemoglobin is bright red in colour, but when it has given up its oxygen its colour changes to dark red.

White Corpuscles. Although large numbers of white corpuscles are present in the blood they are less numerous than the red. They are colourless and vary both in size and form. Unlike the red blood corpuscles, the white corpuscles constantly change their shape and are capable of movement. Their work is to destroy disease germs that find their way into our bodies.



How a white corpuscle catches and digests a germ (highly magnified)

1-3, *a white corpuscle approaching a germ*; 4-6, *how the germ is digested.*

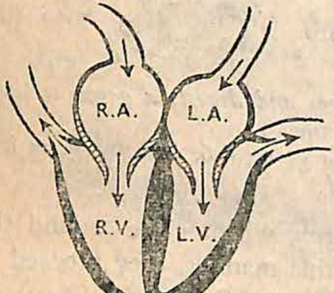
They do this by throwing out arms which close around the germs. Having captured them in this manner, they proceed to digest them. They are not always successful in their efforts and are sometimes killed by the germs instead. When this happens, illness may result.

The Plasma. About 90 per cent of the plasma is water in which several important substances are contained in solution. Digested food absorbed by the small intestine passes into the blood and is then transported to all parts of the body by the plasma. Wastes from all the cells of the body also pass into the plasma and are carried to places such as the lungs and the kidneys where they are finally got rid of.

One of the substances dissolved in the plasma is a protein called fibrinogen. When any part of the body is cut, bleeding results. White corpuscles immediately rush to the spot to attack any germs which attempt to enter the wound. Those that die in defending the body, together with the germs that also die in the battle, form 'pus'. Meanwhile the blood cells that were damaged when the cut was made mix with the fibrinogen to form an insoluble substance. This substance forms a cottony network of fibres across the wound to make a solid clot of blood, that seals off the wound and prevents further loss of blood. Red corpuscles entangled in the threads gives the clot its red colour.

The Heart. Blood is pumped round the body by the muscular action of the heart. It lies in the chest between the lungs and is about the size of a cricket ball.

If the heart is cut open it will be seen to consist of four chambers. There is no communication between the chambers on the right and those on the left. The two upper chambers are called auricles, and the two lower chambers are called ventricles.

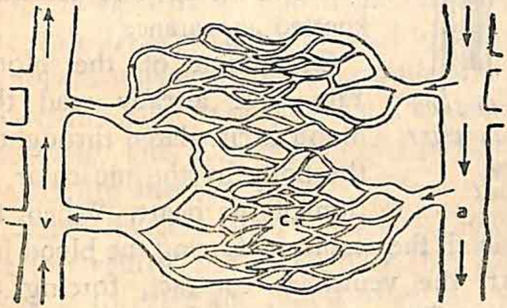


Diagrammatic section of the heart to show the chambers and the direction of blood flow: R.A., right auricle; L.A., left auricle; R.V., right ventricle; L. V. left ventricle.

Between the auricle and the ventricle on each side of the heart and also between each ventricle and the tube that leads away from it is a valve. These valves allow blood to flow in only one direction.

Arteries, Veins and Capillaries. There are three kinds of tubes which transport blood around the body. These are the arteries, veins and capillaries. Arteries carry blood away from the heart while veins bring blood back to the heart. Capillaries connect arteries to veins.

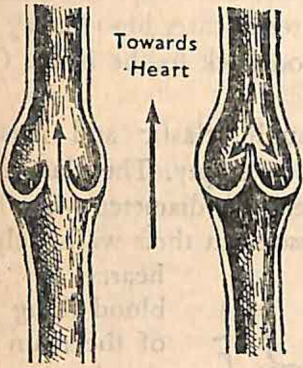
The arteries have strong, tough, elastic and muscular walls. They do not collapse when empty. The elasticity of their walls enables them to increase in diameter when blood is forced into them, and the muscles in their walls help the heart to force blood along. Each of the main arteries that leave the heart is almost an inch in diameter. They grow progressively smaller, the further they are from the heart, and finally, after repeatedly dividing and sub-dividing, they give rise to the capillaries.



Diagrammatic section of artery (a), capillaries (c), and vein (v).

The great network of capillaries is a very important part of the circulatory system. They are fine, hairlike tubes with very thin walls. The diameters of these tubes are so small that red blood corpuscles can only pass through them in single file.

The capillaries gradually link up again forming larger and larger veins which in turn open into the great veins leading back to the heart. The walls of the veins are similar in structure to the arteries, except that they are much thinner and not nearly as elastic or muscular. On account of this, veins collapse when empty. In many veins there are valves which allow blood to flow only in the direction of the heart. These valves are most abundant in those veins which pass along the arms and legs. If you put your arms by your sides you will make the blood flow backwards on the valves thus causing the veins in your hands to fill out and present a knotted appearance.



Diagrammatic section to show how the valves work in veins
Left: *valves open*
Right: *valves closed*

Circulation of the blood. You have already read that blood is circulated throughout the body by the muscular action of the heart. When the auricles are full of blood, they contract, forcing the blood into the ventricles. Next, the ventricles contract, forcing the blood into the arteries. The contraction of the auricles and ventricles is counted as one beat of the heart. Immediately after the contraction of the ventricles the muscular walls of the auricles relax, allowing the blood in the veins to refill the upper chambers again.

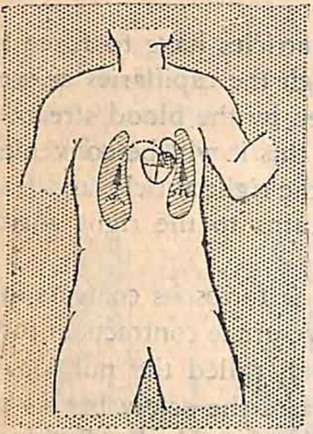
If you look at the diagram on page 178 you will notice that the muscular walls of the auricles are thinner than the walls of the ventricles.

This is because the auricles have merely to force the blood into the ventricles, whereas the ventricles have to force the blood down the arteries and through the capillaries as well.

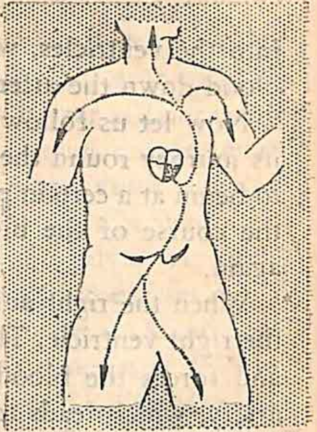
Now let us follow the path taken by the blood stream in its journey round the body. To do this it will be convenient to begin at a certain point, such as the right auricle, and trace the course of the blood till it returns to the right auricle again.

When the right auricle contracts, it forces its contents into the right ventricle. Then the right ventricle contracts in turn, and forces the blood into an artery, called the pulmonary artery, which leads to the lungs. Here the artery breaks up into capillaries. Waste carbon dioxide brought by the blood passes into the lungs through the walls of the capillaries while oxygen passes out of the lungs into the blood flowing through the capillaries. The red blood corpuscles absorb this supply of oxygen. From the capillaries of the lungs the blood passes into tiny veins which join together to form the pulmonary vein. This vein conveys the blood, which is now rich in oxygen, to the left auricle.

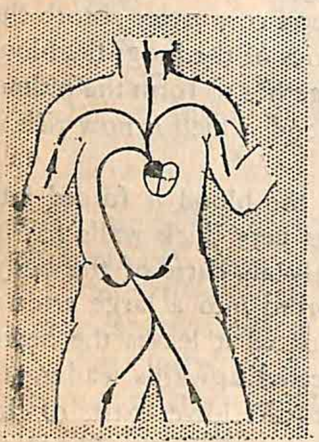
When the left auricle contracts, the blood is forced into the left ventricle. This chamber has very thick walls for its work is to drive the blood to nearly all parts of the body. When it contracts, the blood is forced into a large arterial trunk called the aorta, which as soon as it leaves the heart, divides into two branches, one directed upwards leading to the arms and head, and the other to the lower parts of the body. Branches leading from the aorta carry the blood to the capillaries in all parts of the body, except the lungs. While in these capillaries the blood gives oxygen to the parts which need it and picks up much carbon dioxide, excess water and other waste matter. The blood flowing through



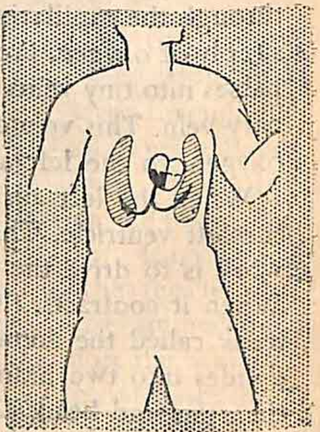
1. Blood absorbs oxygen from the lungs and enters the left auricle. It passes to the left ventricle



2. When the left ventricle contracts blood is forced out along the arteries to the body.



3. After passing through capillaries in the tissues and losing oxygen the blood returns to the right auricle.



4. Blood passes into the right ventricle which contracts and forces blood out to the lungs.

—— Blood containing little oxygen (de-oxygenated)

------ Blood containing much oxygen (oxygenated)

What the chambers of the heart do

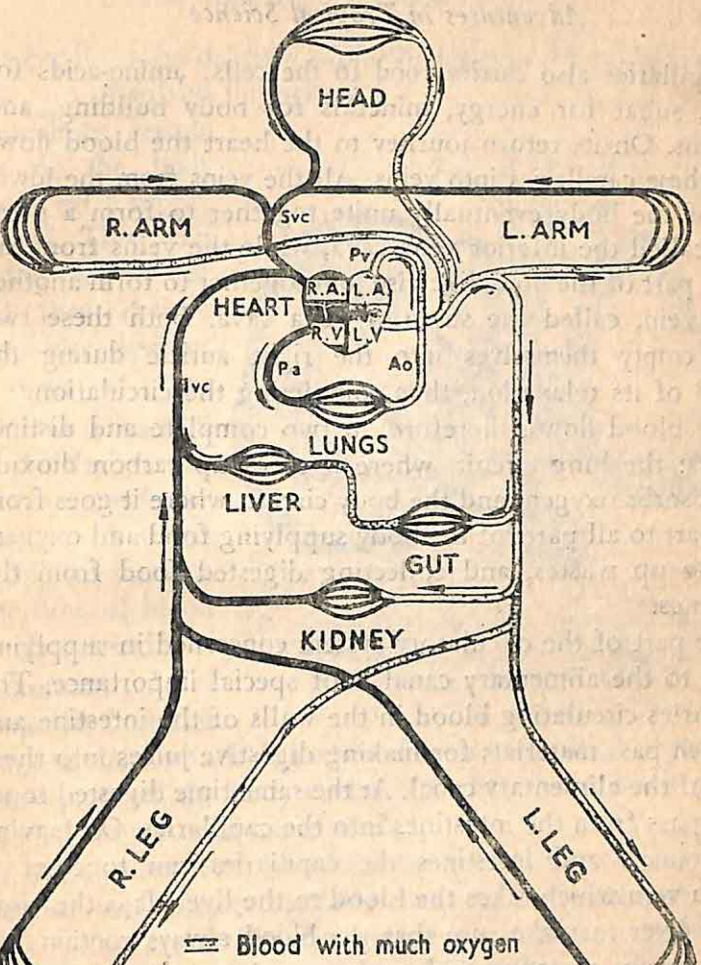


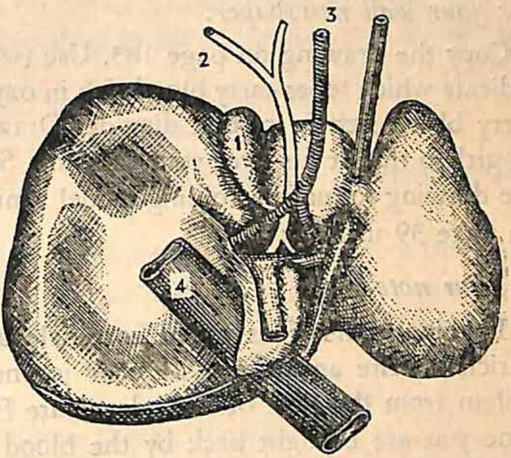
Diagram illustrating Blood Circulation.
Arrows point in the direction of blood flow.
R.A., right auricle; L.A., left auricle; R.V., right ventricle; L.V., left ventricle; Pa, pulmonary artery; Pv, pulmonary vein; Ao, aorta; Svc, superior vena cava; Ivc, inferior vena cava.

the capillaries also carries food to the cells: amino-acids for repair, sugar for energy, minerals for body building, and vitamins. On its return journey to the heart the blood flows from these capillaries into veins. All the veins from the lower part of the body eventually unite together to form a great vein, called the inferior vena cava, while the veins from the upper part of the body likewise join together to form another great vein, called the superior vena cava. Both these two veins empty themselves into the right auricle during the period of its relaxation, thus completing the circulation.

The blood flows, therefore, in two complete and distinct circuits: the lung circuit, where it gives up carbon dioxide and absorbs oxygen, and the body circuit, where it goes from the heart to all parts of the body supplying food and oxygen, picking up wastes, and collecting digested food from the intestines.

The part of the circulatory system concerned in supplying blood to the alimentary canal is of special importance. The capillaries circulating blood in the walls of the intestine and stomach pass materials for making digestive juices into these parts of the alimentary canal. At the same time digested foodstuffs pass from the intestines into the capillaries. On leaving the stomach and intestines the capillaries run together to form a vein which takes the blood to the liver. It is the work of the liver to make sure that the blood always contains the exact amount of amino-acids and sugar that the body requires. If there is excess, the liver stores these materials until needed.

Besides carrying food and oxygen, the blood also carries a variety of wastes such as excess water, carbon dioxide and certain kinds of dissolved impurities. These wastes are transported to two chief dumps: the lungs and the kidneys. The lungs expel carbon dioxide, while the kidneys get rid off excess water and dissolved impurities.



The Liver and the tubes connected to it
1. gall-bladder; 2. tube leading to duodenum; 3. artery; 4. vein.

Sometimes certain parts of the body want an extra supply of blood. They can get the supply of blood they require without any need for the heart to beat faster than its normal rate. At the conclusion of a meal, for example, there is need for an increase in the flow of blood through the walls of the stomach. As a consequence, arteries leading to the stomach dilate and fill up with blood. Arteries in other parts of the body contract so that the stomach may receive the supply of blood it needs.

On certain occasions, however; the heart beats faster than its normal rate. After vigorous exercise, for example, the muscles concerned require more than their usual supply of oxygen. This means that more blood must flow to them. To bring this about the heart beats at an increased rate.

Things to make and do

Visit the butcher:

There is not a very great difference between the heart of a sheep and that of a human being. Obtain a sheep's heart from the butcher and examine it closely.

For your wall newspaper:

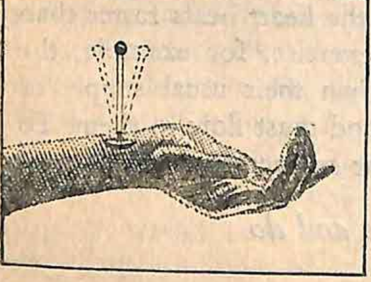
Copy the drawing on page 183. Use two separate colours to indicate which tubes carry blood rich in oxygen and which tubes carry blood rich in carbon dioxide. Draw a picture of a boy or girl so that it fits over your drawing. Stick this picture over the drawing to make a folding model similar to the one shown on page 39 in Book 2.

In your note-book:

Imagine yourself as a red corpuscle arriving in the right auricle. Write an account of your journey in the circulatory system from the time of your departure from the heart to the time you are brought back by the blood stream to the right auricle.

A match trick:

When the blood is forced into the arteries by the contraction of the ventricles, the walls of the arteries bulge out a little to accommodate this extra amount of blood. Consequently, there is a regular alteration in the diameter of the arteries which can be felt as far from the heart as the wrist, and is known as the pulse. In fact, it can be felt wherever an artery passes over a bone. Another place to feel the pulse is at the side of the forehead.



How to magnify your pulse

You can magnify your pulse with the help of a matchstick. Stick a drawing-pin into one end of a matchstick and place the arrangement over your pulse as shown. The matchstick moves back and forth corresponding in its movements to the beat of the heart.

Fill in the blanks:

Choose the correct words from this list and use them to fill in the blank spaces:

left ventricle, oxygen, intestines, vena cava, red, wastes, to, lung, tubes, veins, white, left auricle, body, auricles, pulmonary vein, from, defend, aorta, valves, connect, corpuscles, two, pulmonary artery, carbon dioxide, capillaries, right auricle, ventricles, plasma, food, four, haemoglobin, blood, right ventricle, heart, oxygen, disease germs, arteries.

The circulatory system consists of the —— and a series of —— through which —— is pumped. The blood consists of a liquid called ——, in which float cells called ——. The —— corpuscles transport —— to all parts of the body with the help of the —— they contain. The —— corpuscles —— the body against attacks from ——. The plasma carries ——, —— and other dissolved substances. The heart consists of —— chambers. The two upper chambers are the —— and the two lower chambers are the ——. —— regulate the flow of blood in the heart. ——, ——, —— transport blood around the body. Arteries carry blood —— the heart while veins convey blood —— the heart. Capillaries —— arteries to veins.

Blood flows around the body in —— distinct circuits. The —— circuit consists of the —— which leads from the —— to the lungs where it breaks up into capillaries that later unite to form the —— which leads to the ——. The —— circuit consists of the —— which leads from the —— to the upper and lower parts of the body where it breaks up into capillaries that later unite to form the superior and inferior —— which leads to the ——. The blood in the lung circuit gives up —— to the lungs and absorbs ——. The blood in the body circuit supplies all parts of the body with food and oxygen, picks up waste matter and collects digested food from the ——.

18

Respiration

In Chapter Sixteen we studied the method by which our bodies obtained a store of energy, by digesting and absorbing those foodstuffs containing it. We will now consider how this energy is produced from the food eaten, and changed into the form necessary to make the cells of our bodies work.

The release of energy. Energy is required for any kind of work. A machine, for example, is supplied with fuel such as petrol, coal or oil, which is burned to make a hot fire. The heat of the fire represents the energy released by the process of burning. This process is actually an oxidation, that is, the fuel is combined with oxygen resulting not only in the production of energy, but also in the formation of carbon dioxide and water.

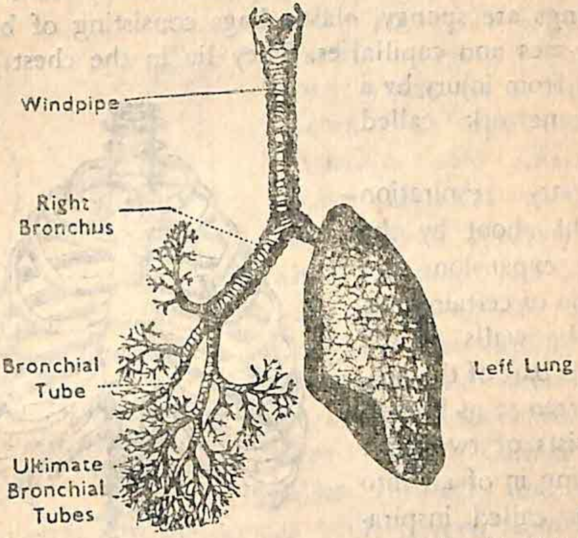
Our bodies, like machines, cannot work unless they are given a regular supply of fuel. Fuel foods, such as carbohydrates and fats, are burned in the cells of our bodies and the energy set free in the form of heat is used by the cells to do work. The burning that takes place is an oxidation. Oxygen required for this process is brought by the red blood corpuscles while carbon dioxide and water, the products of oxidation, are carried away by the blood stream.

From what you have just read it is clear that oxidation in machines and in our bodies is similar in many respects. Nevertheless, there are certain important differences. One of these differences is that our cells do not burn the fuels supplied to them at a temperature high enough to make a flame. The heat produced however, is sufficient to keep our temperature at 98.4°F. During vigorous exercise we need an extra supply of energy. Consequently, burning takes place more quickly in our bodies, and we feel ourselves becoming warmer. The heat produced in the muscles does not remain there, but is distributed all over the body by the blood. The normal temperature of the body is thus maintained.

Respiration. Generally speaking, the term respiration includes all those processes involved in the releasing of energy from absorbed food. This process goes on in every cell of the body. It is largely concerned with the exchange of two gases, oxygen passing from the air into our bodies and carbon dioxide passing from our bodies into the air. This is brought about in two stages. In the first stage, called pulmonary respiration, oxygen passes from the lungs into the capillaries while carbon dioxide passes from the capillaries into the lungs. In the second stage, called internal respiration, oxygen passes from the capillaries into the cells situated in various parts of the body, while carbon dioxide passes from the cells into the capillaries.

Pulmonary respiration. We have already seen the necessity for a supply of oxygen reaching the various cells in the body so that the energy locked in the fuel foods may be released, and used by the cells for their activities. Further to this, it is essential that carbon dioxide, the product of the activities going on in the cells, is expelled. Let us now consider the structures that move air in and out of the lungs and provide for the transfer of oxygen from the lungs to the blood, and carbon dioxide from the blood to the lungs.

The greater part of the air which enters the body passes through the passages of the nose called nostrils. Here it is warmed, moistened and filtered before going into the nasal

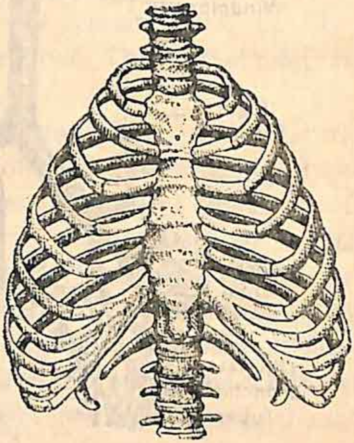


The Lungs, one being opened to show the Air Tubes

cavity that lies behind the nose and mouth. The filtering is done by the numerous hairs that line the nostrils. These hairs trap dust particles and allow only clean, warm air to pass down the windpipe from the nasal cavity to the lungs.

The windpipe is always kept open for the passage of air by numerous hoops, of cartilage. If you run your fingers down your throat you will feel these hoops. The windpipe branches at its lower end into two tubes called bronchi. Each of these tubes leads to a lung. In each lung the tube divides into a number of smaller tubes that further sub-divide into minute tubes, as thin as hairs, called bronchial tubes, which, in their turn, lead into very tiny air-bags called air-sacs. These air-sacs have extremely thin walls which are surrounded by capillaries, that bring blood to them and carry blood away from them.

The lungs are spongy, elastic bags consisting of bronchial tubes, air-sacs and capillaries. They lie in the chest and are protected from injury by a bony framework called the ribs.


The Ribs

Pulmonary respiration is brought about by the alternate expansion and contraction of certain muscles in the walls of the chest. This part of the process, referred to as breathing, consists of two acts: the drawing in of air into the lungs called inspiration, and the forcing out of air from the lungs called expiration. The lungs themselves are passive during breathing, for they have no muscles; but since they are elastic they are able to stretch and recoil as the pressure exerted on them varies within and without.

During inspiration the muscles attached to the ribs contract, raising the ribs and thus enlarging the chest cavity from front to back as well as from side to side. At the same time, a sheet of muscle called the diaphragm contracts, descends downwards. and enlarges the chest cavity from top to bottom. As the chest cavity thus widens and deepens air rushes in and inflates the lungs. At the end of inspiration, the muscles relax and fall back into their normal positions. When the diaphragm relaxes, it arches upwards like a dome into the chest and exerts pressure on the lungs. This results in expiration.

The lungs are supplied with blood by means of the pulmonary artery which, no sooner than it reaches the lungs, divides and sub-divides into smaller and smaller branches until at last they form a capillary network which surrounds and lies on the walls of the air-sacs. The blood brought by these capillaries is poor in oxygen and rich in carbon dioxide. Gaseous exchange now takes place. Carbon dioxide passes through the walls of the capillaries into the air-sacs while oxygen from the air in the air-sacs passes through the walls of the capillaries into the blood stream. In due course the carbon dioxide in the air-sacs is breathed out, and the blood leaving the lungs, now rich in oxygen, is collected by small veins which eventually carry the blood to the pulmonary vein. This great vein transports its contents to the heart to be pumped round the body.

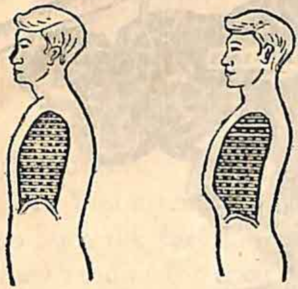
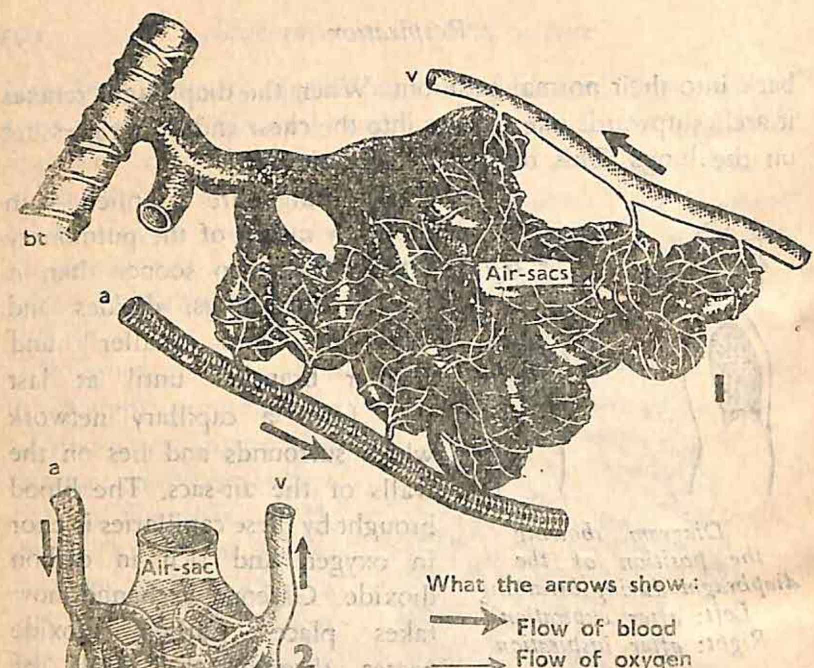


Diagram showing the position of the diaphragm during breathing
Left: after expiration
Right: after inspiration

Internal respiration. The cells in all parts of the body, as we have seen, are continually using up oxygen for burning up food material, while at the same time they are continually producing carbon dioxide and other waste products. Blood pumped from the heart through the aorta is rich in oxygen. This blood ultimately reaches the cells by way of the capillaries into which the aorta finally divides. Interchange of gases



1 and 2. To show how the capillaries circulate blood among the air-sacs. 3. To show the interchange of oxygen and carbon dioxide in the lungs and the cells.

a, artery; v, vein; bt, bronchial tubes.

now takes place between the blood in the capillaries and the cells. Oxygen passes through the walls of the capillaries into the cells, while carbon dioxide and other waste products pass from the cells into the capillaries. The blood leaving the cells is therefore richer in carbon dioxide and poorer in oxygen than when it came to the cells. The capillaries leaving the cells reunite to form veins which carry the blood back to the heart.

Things to make and do

Outdoors:

1. You already know that during respiration oxygen is used to burn the fuel foods in the cells and so produce the energy they require for their activities. Breathing is the outward sign of respiration. Under certain conditions, such as after a quick run, the cells of the muscles demand more than their usual supply of oxygen to meet their energy requirements. This results in faster breathing. The rate of breathing, that is, the number of breaths taken per minute does not only vary according to what a person is doing, but also varies with age. Conduct your own investigation to prove that what you have just read is true. Prepare a report of your investigation and illustrate it by constructing horizontal bar graphs.*

2. Deep breathing exercises must be done regularly. Such exercises help to purify the blood. There is no danger that the burning taking place in the body will proceed more rapidly than usual, for the body makes use of only the oxygen it requires and whatever is not needed is breathed out.

In your note-book:

Write a summary of this chapter.

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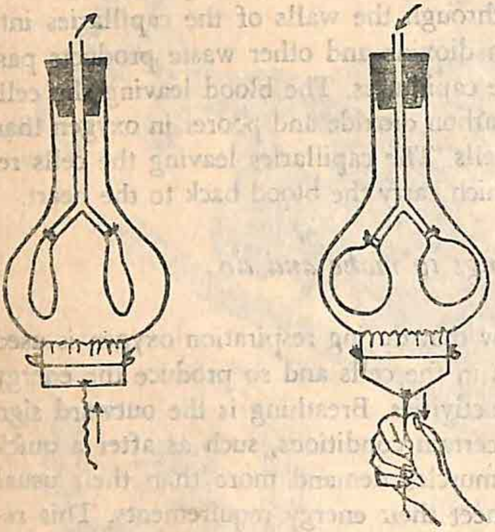
* Book 2, p. 5.

A model which shows how the lungs work:

Fit a one-holed stopper to the neck of a lamp-chimney (or a bell-jar). Insert a Y-tube through the stopper. On each of the forked tubes tie a small rubber balloon. Next, tie a sheet of rubber (or a sheet of brown paper) round the bottom of the lamp-chimney with a piece of string knotted through a hole. Seal the hole with wax.



Apparatus for demonstrating how the movements of the diaphragm helps us to breathe. The arrows show the direction of the flow of air

Materials used	*What they represent*
Y-tube	*Windpipe and bronchi*
Balloons	*Lungs*
Chimney	*Chest cavity*
Rubber sheet	*Diaphragm*

The model you have made corresponds to some extent with the breathing mechanism of the body. Look at the diagram on page 196 and note which parts of the apparatus correspond to parts of the body concerned with breathing.

When you pull the string the sheet of rubber is lowered and the air in the chimney expands. As a result the pressure of the air in the chimney is lowered and the air outside the apparatus, which is under atmospheric pressure, rushes down the Y-tube and fills the balloons. By releasing the string or pushing the sheet of rubber upwards, you put pressure on the air in the chimney and this forces the air out of the balloons.

For your wall newspaper:

Obtain two sheets of graph paper and make area graphs to show how the air breathed in differs from the air breathed out. Divide the first sheet of paper into a hundred equal squares. Colour 79 squares blue to represent nitrogen, and 21 squares red to represent oxygen. The completed graph will give you an idea of the composition of the air breathed in. Divide the second sheet of paper into a hundred equal squares as well. Colour 79 squares blue to represent nitrogen, 16½ squares red to represent oxygen and 4½ squares green to represent carbon dioxide. This graph will give you an idea of the composition of the air breathed out.